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What's Your Best Record for Inserting Coils In a Stator

And completing the job ready for making the end connections of the coil groups?

ON A TRIP through the South some time ago I chanced to visit the repair shop in Charlotte, N. C., operated by L. F. Stratton and his two sons. After seeing some time- and money-saving methods in making coils, stripping armatures, inserting coils in stators and the like, I had a good, long talk with L. F. Stratton himself—a treat I am going to give myself again soon, for in a couple of hours he told me more things about repair shop work that is right and wrong than any one I have met in a long time.

After returning to my own job I rolled over in my mind the details of a job that Mr. Stratton told me about, which concerned a time test for inserting forty-eight coils in the stator of an old-style G. E. motor. In a letter I asked him to check my memory that the time for *completing the job* was one hour and forty-three minutes. In reply he gave full details and stated that the time mentioned was correct for inserting the coils with the insulation cut and inserted before starting and the coils taped at the ends. I then wrote Mr. Stratton the following letter which drew the masterpiece quoted below:

DEAR MR. STRATTON:

I have read your letter twice already and am going to read it again as soon as I can find the time. I recall with decided pleasure my visit with you and I want to assure you that I shall try to work out the problems we discussed and write you about my own troubles, knowing that I will get a real reply.

In reference to the time it took you to insert 48 coils in a 5-hp. motor I recall the story of two boys who were found by a good preacher on the street fighting over a dog. Upon inquiring the cause of the trouble one boy said that they had found the dog and decided that the fellow who could tell the biggest lie as to how they found it could have it. The preacher said, "Boys, this is all wrong. When I was your age I never fought with other boys over such a matter as this." Whereupon the bigger boy said, "Mister, take the dog."

Of course this story doesn't prove anything conclusive concerning your speed in inserting coils. I am glad to have the information you gave me and if I discover anyone who can take the dog from you I shall certainly let you know.

And this is Mr. Stratton's reply:

I have your letter. Thank you.

After nurturing the belief that Solomon had nothing on my wife's husband, except the number of wives he annexed, I am more than ordinarily offended when you tell me you read my letter twice, and that another reading will be necessary (we assume) to get any sense out of it. This is the most violent jostle that my ego has had recently, and you'll better understand what that means when I tell you that I have been married thirty-four years, and that Mrs. Stratton is a Missourian.

The pup, the belligerent kids and the Eminent Divine appear to be made especially to fit my case. I never did have a fondness for mutts; so let 'em have the dog, I don't care. I learned long since that if you cherish an ambition for a prevarication diploma you must restrain your desire to go over the top until the last man has placed his cards—all of 'em—face up on the table. I'm more than ordinarily expert (sure 'nuf) when the necessity or desire attacks me to run the whole Gamut, Chromatic Scale and all, in distorting the facts, but my experience has demonstrated that it's only the last man at the bat who has a ghost of a show as a liar of merit.

However, the scientific and speculative side of electricity rather demands that we use two crutches or nothing less than a crutch and cane if we walk at all. The mechanical side appeals to us, including motion studies and the elimination of gestures that count only in the weekly pay sheet or result in the prolongation to two hours of a job that should take as many minutes.

We still remember you as among those it would be a delight to see frequently. With best wishes.

I want to go to Charlotte soon and if any reader thinks he has Mr. Stratton beaten on inserting forty-eight coils in a stator, I would like to get the details of the job. And by the way, if you are ever near the Stratton shop make it a point to drop in and call for L. F. S. himself—you will have a good time and get both eyes and ears full of things you would like to know.

Practical Pete

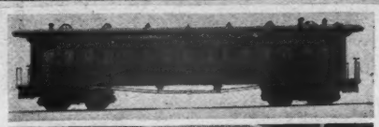
A Glimpse into the

Works of The Pullman Company

Where a plan for increasing comfort of travel has resulted in a large manufacturing and operating organization. The ninth of a series devoted to the growth and extent of our basic American industries.

IN THE early days of railroad travel the lines were short and at first it was thought impossible to operate trains at night. The first sleeping car, in 1836, consisted of a day coach divided into four compartments, each with a row of seats along one side and three tiers of berths or bunks without bedding along the other.

In the early fifties George Mortimer Pullman was impressed during a night trip with the advantages to the traveling public of a service contributing safety, convenience, luxury, and a thorough and uniform service even though on a long journey. It was not until 1858 that he had the opportunity to apply his ideas to tests, when a Chicago & Alton passenger coach was made over into a sleeper—historic "No. 9." This introduced Mr. Pullman's invention of upper berths which might be closed in the daytime and serve as receptacles for bedding. From this small beginning, many improvements have been made in convenience, comfort and safety through six-wheel trucks, electric lights, all-steel anti-telescoping frames and other features.



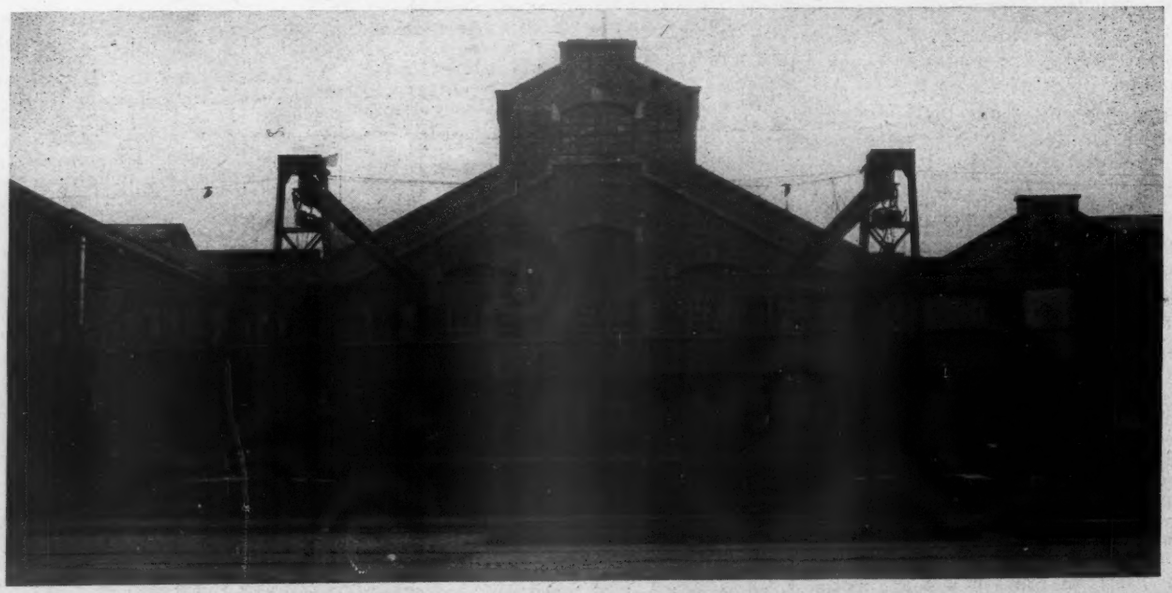
How the first Pullman car compares with one of today.

The first Pullman, "No. 9," was made from a rebuilt passenger car. In this the upper berths were suspended by ropes and pulled up overhead during the daytime. From this basic idea has evolved the modern, all-steel Pullman. The interior view shows the new type of day-time semi-privacy sleeper with permanent partitions between berths making semi-compartments of sections.

The next step was the organization of departments to manufacture and operate these cars over many railroads. Today, Pullman service extends over practically the entire United States. The longest run is between Washington, D. C., and San Francisco, Calif., a distance of 3,606 miles. The Pullman Company supplies a reservoir of cars for handling un-

Placing the whole side of a Pullman car in position.

One of the most interesting operations in the construction of a Pullman car consists in the method of building the body. The underframe is assembled on trucks as shown below. Both sides and the top are assembled in special jigs or templets, lifted by two hoists, as shown here, slipped into position and riveted.



usual or peak service. About 5,864 of its 7,665 cars are in daily service with over 1,000 more required during peak travel periods.

The Operating Department has 23,500 employees of whom about 10,000 are porters. Another 4,000 are employed as car cleaners and 4,000 additional in repairing cars. Over 300,000,000 pieces of linen are laundered each year.

In the manufacturing organization 10,400 people are employed in building both passenger (in addition to Pullman) and freight cars in the 150 factory buildings covering 600 acres of land, Including the Haskell & Barker plant at Michigan City, Ind., and the Pullman plant in Chicago, The Pullman Company can build monthly 3,500 new freight cars and repair at its shops 375 in addition, as well as build 125 passenger cars.

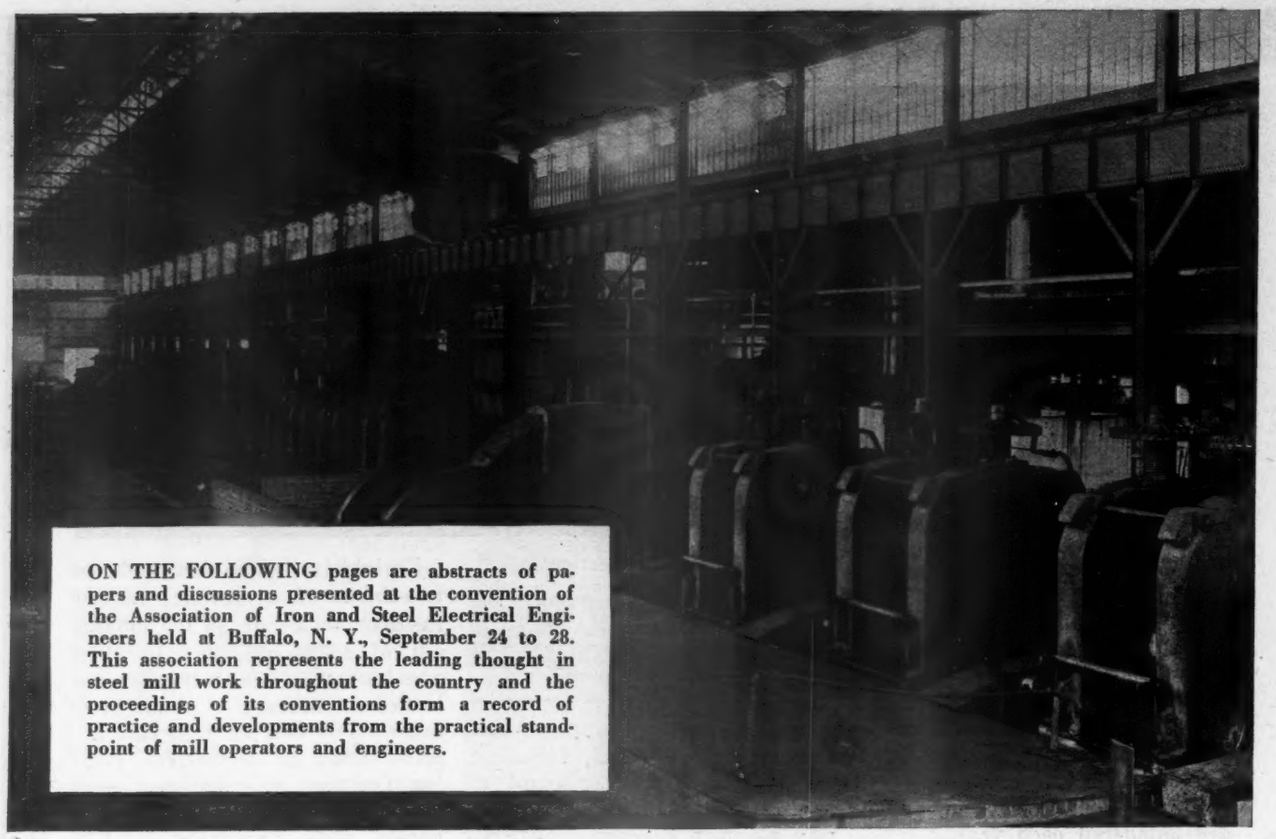
Two extremes in fabrication.

The view at the right shows the fabrication of the steel framework which gives strength and safety to the car. All the interior except the upholstery, bedding, and similar material is of steel. The view at the left shows some of the miscellaneous sewing required.

Freight transportation produces two-thirds of all revenue of the railroads — about $4,320,000,000 out of $6,225,000,000. In 1919 over 1,100,000,000 passengers were hauled an average of about 41½ miles. For this all railroads received about $1,250,000,000. During the past year Pullman cars carried an average of 90,000 passengers daily approximately 375 miles per trip. The net operating income last year was about 24 cents per Pullman passenger or $2.84 per day for each car owned.

Three views in the Pullman shops.

Each of the plates used in the side of a Pullman car is laid out and punched according to a templet, so that when assembled all will fit together perfectly. The view below, shows the axle shop. Special lathes drive the axle from the center so that tools can work on both ends at the same time. The view at the right shows the battery-charging department of the Calumet repair shop, where a large variety of miscellaneous repairs and refinishing is handled. About 4,000 men are employed in this work regularly. In addition there are sixteen linen repair shops and several general and division storehouses.



ON THE FOLLOWING pages are abstracts of papers and discussions presented at the convention of the Association of Iron and Steel Electrical Engineers held at Buffalo, N. Y., September 24 to 28. This association represents the leading thought in steel mill work throughout the country and the proceedings of its conventions form a record of practice and developments from the practical standpoint of mill operators and engineers.

Some of the

Problems of Steel Mill Operation

Which Are Now Faced or Have Been Successfully Worked Out in Practice During the Past Year or Two

AT THE seventeenth annual convention of the Association of Iron and Steel Electrical Engineers, held in Buffalo, N. Y., September 24 to 28, papers were presented on a wide variety of subjects of interest to men in charge of blast furnace, rolling mill and associated operations. These papers presented the viewpoint of the operating electrical and mechanical engineer, and their authors represented the following companies: Carnegie Steel Co., Bethlehem Steel Co., Babcock & Wilcox Co., Inland Steel Co., Ohio Steel Foundry Co., Minnesota Steel Co., Worth Steel Co., New Jersey Zinc Co. and Halcomb Steel Co.

In what follows abstracts are given of papers dealing with electrical and associated mechanical systems, with main points of the discussions.

Electrical Development Committee

By WALTER C. KENNEDY,

Chairman and Operating Engineer, Worth Steel Company, Claymont, Del.

THE Electrical Development Committee reports submitted each year and published by this association are intended to note the developments occurring during the respective years. The report then is intended to cover developments that have become active or particularly noticeable during the past year.

The subject of ever-absorbing interest to the steel mill electrical engineer is the rapidly increasing list of main-drive applications. Since the very first installation of this kind this list has been rapidly growing from various causes and this year has been no exception to the rule. Sixty-two installations are recorded in an accompanying table.

There are many interesting features in connection with the installations, but there seems to be three prominent features that should be called to our attention:

1. The large number of motors replacing steam engines.
2. The extent to which gears have been used.
3. The use of direct current exclusively on several adjustable speed applications.

It is gratifying to know that the electric drive has so far proven its

superiority in regard to economy of operation that it is now replacing more than ever the steam-engine-driven equipments. When we consider that the first electric drive for a reversing mill, to replace a steam engine, was sold in 1917 to the Lackawanna Steel Company, but which was not put into operation until 1921, the growth for this line of work especially has been phenomenal.

The rapid increase in the use of electric drive may be due to three causes:

1. The increasing cost of coal and, therefore, steam.
2. The increasing availability of reliable purchased power.
3. The development in gear drive.

All of the above developments, of course, have been gradual, but it is now a recognized fact that in many cases a steel plant may buy purchased power at a better figure than they can make it and at the same time reliable enough to be considered for steel mill service. In many cases steam engines would probably not have been replaced had it not been possible to purchase power.

In regard to the third reason, purchased power is in nearly every case 60-cycle if purchased from any of the public utility companies. For main roll equipment the use of 60-cycle power practically means a gear reduction, and here is seen one great development in this art which has required several years to accomplish. At one time a gear reduction on a main rolling mill drive was a questionable point, but now this form of drive, through its development, has become so reliable that there is no further question as to its use for this service. In many cases the flywheel is directly mounted on the motor shaft and the gear reduction, therefore, has to stand severe shocks of rolling. Even these equipments have given good service and, therefore, the success of the gear drive has really helped to a large extent to increase the number of motor applications through the use of purchased 60-cycle power.

Referring to the various items, there are several points of interest to be noted.

Plants 7, 14, 19, 20, 22, 40, 41 and 51 replaced steam engines. Operators are realizing more and more that they cannot afford to keep these old steam engines in operation. They are inefficient in their use of steam and require constant attendance and maintenance. It is not an uncommon thing from saving of attendance, maintenance and repairs to more than pay for the fixed charges on the electrical installation, leaving a saving in power consumed as sure profit. The steam-driven mill is slowly but surely being supplanted.

Plants 19, 20, 21, 30, 40 and 60 are of interest as being geared drives of large capacity. A 6,250-hp. installation for Inland Steel Company will be the largest geared drive in this country. It was formerly the practice to direct connect the driving motor to the lay shaft on continuous mills. On late installations, however, most of the drives are geared.

Plants 7, 40, 58 and 59 are drives of the Ilgner type, consisting of direct-current motors supplied with power from flywheel motor-generator sets. The drives for the Cia Sederurgical del Mediterraneo at Sagunto, Spain, are only part of a large order including all electrical equipment

Steel Plants Now Using Electric Motors on Main Drives

No.	Company	Motors No.	Motors Hp.	Volts	Cycles	R. p. m.	Mill	Connection
1	Am. Rolling Mill Co.	2	2000	6600	60	505	Rolling	Gear
2	Am. Rolling Mill Co.	2	600	2200	60	885	Rolling	Gear
3	Am. Rolling Mill Co.	2	500	2200	60	575	Rolling	Gear
4	Am. Rolling Mill Co.	4	400	2200	60	575	Rolling	Gear
5	Am. Rolling Mill Co.	10	300	2200	60	575	Rolling	Gear
6	Atlas Steel Corp.	1	700	240dc		135/360	10-in. Merchant	Direct
7	Bethlehem Steel Corp.	1	7000	700dc		0/120	40-in. Blooming	Gear
8	Bethlehem Steel Corp.	1	300	2200	25	750	10-in. Bar	
9	Buckeye Rllg. Mill Co.	1	1000	4000	60	720	18-in. Rail reroll.	
10	Calumet Steel Co.	1	400	4000	60	585	Slitting stand	Gear
11	Columbia Steel Co.	1	1500	2200	60	360	Sheet	
12	Columbia Steel Co.	1	1800	2200		514	Rod	
13	Dilworth Porter	1	700	2200	60	390	18-in. Bar	Gear
14	Firth Sterling Steel Co.	1	550	250dc		120/300	10-in. Merchant	Direct
15	Follansbee Bros. Co.	1	500	2200	60	442	Cold Sheet	Gear
16	Holcomb Steel Co.	1	620–200	440	60	321/107	9-in. Merchant	
16A	Holcomb Steel Co.	1	500–250	440	60	130/65	14-in. Merchant	
17	Ford Motor Company.	1	8000	13200		240	Blooming	Direct
18	Ford Motor Company.	1	4500	500dc		67½/110	14-in. Merchant	
19	Illinois Steel Co.	1	5000	6600	25	370	132-in. Plate	Gear
20	Illinois Steel Co.	1	5000	6600	25	370	90-in. Plate	Gear
21	Inland Steel Co.	1	6250	2200	25	368	24-in. Cont. billet	Gear
22	Inland Steel Co.	1	1500	2200	25	368	Sheet bar finish	Gear
23	Inland Steel Co.	1	4500	2200	25	300/500		
24	Inland Steel Co.	1	4500	1500dc		67½/110	14-in. Merchant	
25	Jones & Laughlin.	1	5750	6600	25	94	18-in. Billet	
26	Jones & Laughlin.	1	5750	6600	25	94	21-in. Billet	
27	Knoxville Iron Co.	1	800	2200	60	900/720	9-in. Merchant	
28	Metal & Thermit Corp.	1	1300	4000	60	360	Sheet	
29	Michigan Steel Co.	1	1500	4600	25	300	Sheet	
30	National Stamping & Enameling Co.	1	3000	2200	60	235	100-in. Plate	Gear
31	Newton Steel Co.	1	2000	2200	60	234	Sheet	Gear
32	Newton Steel Co.	1	300	2200	60	340	Cold sheet	Gear
33	Otis Steel Co.	1	6500			0/120	40-in. Reversing blmg.	Direct
34	Otis Steel Co.	1	1800	6600	25	500	20-in. Strip	
35	Otis Steel Co.	3	1500	600dc		280/420	20-in. Strip	
36	Otis Steel Co.	3	1800	600dc		115/230	20-in. Strip	
37	Otis Steel Co.	1	3000	6600	25	375	24-in. Sheet bar	
38	Otis Steel Co.	5	375	230dc		430/860	Cold strip	Gear
39	Otis Steel Co.	1	350	2200	25	242	Cold strip	Gear
40	Phoenix Iron Co.	1	3000	600dc		0/485	24-in. Structural	Gear
41	Phoenix Iron Co.	1	2500	2200	60	500	22-in. Bar	Gear
42	Pgh. Crucible Steel Co. Midland, Pa.	1	2500	6600	25	150	Billet	
43	Standard Underground Cable Co.	1	300	2200	60	575	Rod	Gear
44	Takata & Company.	1	1000	2200	60	293	Sheet	Gear
45	Timken Roller Bearing Co.	1	800	230dc		410/720	16-in. Roughing	Gear
46	United Alloy Steel Co	1	360	230dc		300/600	Merchant	Direct
47	Youngstown Sheet & Tube Co.	1	2000	2200	60	234	Sheet	Gear
48	Youngstown Sheet & Tube Co.	1	400	220	25	375	Tube	
49	Youngstown Steel Co.	1	1200	2200	60	505	29-in. Roughing	Gear
50	Youngstown Steel Co.	1	1500	2200	60	705	24-in. Finishing	Gear
51	Washburn Wire Co.	1	1000	2200	60	710	20-in. Blooming	Gear
	COPPER AND BRASS MILLS							
52	Am. Insulating Iron & Cable Co.	1	600	440	60	360		
53	Am. Insulating Iron & Cable Co.	1	600	440	60	900		
54	American Brass Co.	1	500	2200	60	600		
55	Taunton New Bedford Copper Co.	1	500	2200	60	600		
56	Western Cartridge Co	1	600	2200	60	514		
57	Western Cartridge Co.	1	500	2200	60	514		
	FOREIGN							
58	Cia Siderurgica Del Mediterraneo.	1	5000	700dc		0/120	40-in. Blooming	Direct
59	Cia Siderurgica Del Mediterraneo.	1	3750	700dc		0/150	24-in. Structural	Direct
60	Cia Siderurgica Del Mediterraneo.	1	3000	5250	50	735	36x111-in. Plate	Gear
61	Consolidated Rolling Mills, Mexico.	1	300	3000	50	750	16-in. Mcht. roughing	
62	Consolidated Rolling Mills, Mexico.	1	500/250	3000	50	750/375	10-in. Mcht. finishing	

complete for these mills: rotary converters, auxiliary motors, control and switching apparatus. The 24-in. structural mill drive for the Phoenix Iron Works is of the Ilgner type, although it will not be reversed in ordinary operation. This type of drive allows the operator to slow the mill down to enter a piece, and then finish at a high speed, thus increasing the tonnage materially. All previous installations of this type and size have made use of direct-connected motors.

During this year the largest a.c. and single-unit d.c. motors for operating main rolls have been purchased by the Ford Motor Company, items 17 and 18. The former is an 8,000-hp., 240-r.p.m., 13,200-volt, slip-ring induction motor, which will be used to drive an interrupted continuous blooming mill built by the Morgan Construction Company. Incidentally, this is the first steel mill induction motor operating at a voltage exceeding 6,600 volts. The single-unit d.c. motor is rated 4,500-hp., 67½/100 r.p.m., 500 volts, and will be used to drive a 14-in. merchant mill. Direct-current power for this motor is supplied by two 2,000-kw., 250-volt synchronous motor generators, the two generators being connected in series to give 500 volts for the motor armature. The synchronous motor driving the 2,000-kw. generator is rated 2,800 kva., 8 pf., 13,200 volts. Excitation for the synchronous motor and d.c. motor fields is obtained from a third 2,000-kw., 250-volt motor-generator, which also supplies some power for auxiliary motors. A fourth duplicate motor-generator is held as a spare.

The largest induction motor with Kraemer system of speed regulation was also purchased during the year by the Inland Steel Company, Indiana Harbor, Ind., item 23. This motor, which will drive a 14-in. merchant mill, is rated 4,500 hp., 300/500 r.p.m., 2,200 volts, 25 cycles.

The electrical equipment for driving the 30-in, reversing Universal skelp mill at the plant of the Youngstown Sheet and Tube Company, which was reported last year, has been installed and is now in operation. This motor replaces a twin simple reversing engine and its performance so far indicates that when the additional continuous reheating furnaces are completed the tonnage records made by the engine will easily be exceeded. The roll motor is a double-unit motor, rated 4,000 hp., continuously, 80 r.p.m. and 11,500 hp. maximum at 75 r.p.m. The maximum speed is 135 r.p.m. The flywheel set consists of a 2,500-hp., 6,600-volt, 25-cycle, 500-r.p.m. induction motor, two 1,800-kw., 650-volt d.c. generators and a 78,000-lb. steel plate flywheel.

The equipment for the Holcomb Steel Company, items 16 and 16A, is of interest in that it covers the first polyphase brush shifting a.c. motors for main roll drives. This type of motor has been developed and applied to other work, as was previously recorded in the 1922 report, but the above installation is the first one being applied to mill drives. Speed control is obtained by two sets of brushes, whose relative position on the commutator is altered by means of a motor-operated brush shifting mechanism. This motor has characteristics practically identical with the double-range Scherbius equipment and fills a long-felt want for an adjustable-speed a.c. drive where the power required is too small to make Scherbius or Kraemer apparatus feasible on account of the high initial cost of very small installations.

As mentioned in last year's report, the tendency towards simplicity of apparatus is still very pronounced. Instead of using complicated arrangements or special a.c. motors for speed variation, the tendency still seems to be toward the installation of d.c. drives, of variable-speed motors and motor generator sets.

Improvements have been made in details of construction of breakers to meet increased mechanical duty imposed by the interruption of heavy power circuits and the severe strains due to tremendous magnetic forces set up by the short-circuit currents occurring in these circuits. These magnetic strains tend to distort conducting members and supporting insulators and disarrange contact details. The interruption of heavy current flow produces severe explosive forces which must be controlled and relieved. The circuit breaker structures have been made adequate for these conditions, which have been determined by extensive field tests. Provision has also been made for the relief of the expulsion of large quantities of oil, which in the past has been a hazard to property and life.

Expansion of the idea of phase isolation in large power plants has also been prominent and several installations of vertical, isolated-phase circuit breakers are under construction. The use of truck-type circuit breakers in which the entire circuit breakers may be wheeled in and out of a compartment and automatically connected to or disconnected from the circuit is extending rapidly in certain services of the more moderate capacities. Considerable activity has also been shown in extremely high voltage work, 220,000-volt breakers having been put into service on systems on the Pacific Coast, while a large number of 154,000-volt breakers has been produced.

The use of electric heating in the iron and steel industry is still continuing to show advancement and development along some novel lines. We have ordinarily considered that electric power for this service in the steel plant has been applied or is more adapted toward making steel in some form of the electric-arc furnace. However, some new applications along this line have come to the front during the past year.

In the July issue of the 1923 proceedings, an adaptation of electric heating on finishing rolls of sheet and tin plate mills was presented by Mr. Gordon Fox. The purpose of such heat is to prevent roll breakage; and, from all accounts from the results obtained, it has been very successful. The principle is one which no doubt would be well adapted to other cases. Further details will not be considered here in this report, but those interested can obtain much valuable information from the July issue referred to above. The method is new, convenient and economical. The application and operation can be so governed as to offer considerable possibility for decrease in roll breakage.

There has also come to our attention this year a very important and interesting application of electric heat for the purpose of generation of steam by electricity. The electric steam boiler or generator is not exactly new, having been used in various parts of Europe for several years, but its development in this country has been within only the last two years and the last year especially has seen the development of large units heretofore not conceived possible or practical. The development in this country has so far exceeded that of any European practice and has occurred along such novel lines that boilers are now being produced which are to be found nowhere

else in the world. This subject has been very capably presented by Mr. P. H. Falter in the July, 1923, proceedings of this association. The electric steam generation has been particularly adaptable where large amounts of power are produced or purchased and where the question of load factor is of prime importance. While ordinarily it would be assumed that they would be of particular service on purchased power, still the developments are now showing that their use is increasing even where electric power is generated at the plant, especially where it is economical or advantageous to keep the load factor constant.

The Brown Company at Berlin, N.H., Mr. George P. Abbott, electrical engineer, have recently installed one three-tank boiler, operating at 22,000 volts, 3-phase, 60-cycle. This boiler is rated at 18,000 kw., or approximately 1,800 b.h.p., producing 54,000 lb. of steam per hour. The Brown Company generate their own power from a hydro-electric power station and it is transmitted to their mills at 22,000 volts, the boiler operating directly on this voltage without the necessity of transformers. The above equipment is intended to operate only on Sundays and other holidays so that an operation of approximately sixty days per year has justified its cost and use.

The resistance furnace still continues to improve and these furnaces are being used regularly on the vitreous enameling processes, which require a higher temperature than that previously obtained with this type of furnace.

High temperature heating elements for installation in modified fuel-fired furnaces are under development.

One of the outstanding developments of the past year is the auto-valve lightning arrester. This is a valve-type arrester, designed for the protection of both line (Type "LV") and station (Type "SV"). It consists of one or more columns of discs separated by minute air gaps. These gaps impart the valve characteristics, as several hundred volts are required to maintain a discharge across each gap. No maintenance is required by this arrester, and only infrequent inspection. It contains no liquid nor any solid dielectric in the path of the discharge. Its operation involves no chemical reaction and is not affected by temperature.

The distribution type is designed for pole, wall or cross-arm mounting. It is light-weight, easily installed and has no live parts exposed. This is the first valve-type arrester ever offered for distribution service. The station type may be placed on any suitable base, in or out of doors. It is unusually small, and compact.

The static condenser has been applied within the last few years to comparatively small power equipments for the purpose of increasing the power factor. While the results have been entirely satisfactory, still much remains to be developed in the way of standardization and adapting such condensers for ordinary commercial work. Development of this line of apparatus has now reached a high state of perfection. A complete line of static condensers for two and three-phase, 2,300 volts, has been developed in four standard unit assemblies—30, 60, 90 and 120 kva. The outstanding feature of this new condenser is its reliability. It is able to withstand all line surges and conditions of over-voltage equally as well as a distribution transformer. Working stresses have been adopted, which places this condenser on the same basis as oil impregnated cables, as far as reliability is concerned. All manufactured units are given the A. I. E. E. test of 2¼ times normal voltage plus 2,000 for one minute.

Special Bearing Committee

By D. M. PETTY,

Chairman and Electrical Superintendent, Bethlehem Steel Company, South Bethlehem, Pa.

THE COMMITTEE on bearings has, during the past year, made a careful study of the problem of applying roller and ball bearings to motors. It has held one joint meeting with a committee representing the Power Club and appointed to study the same problem.

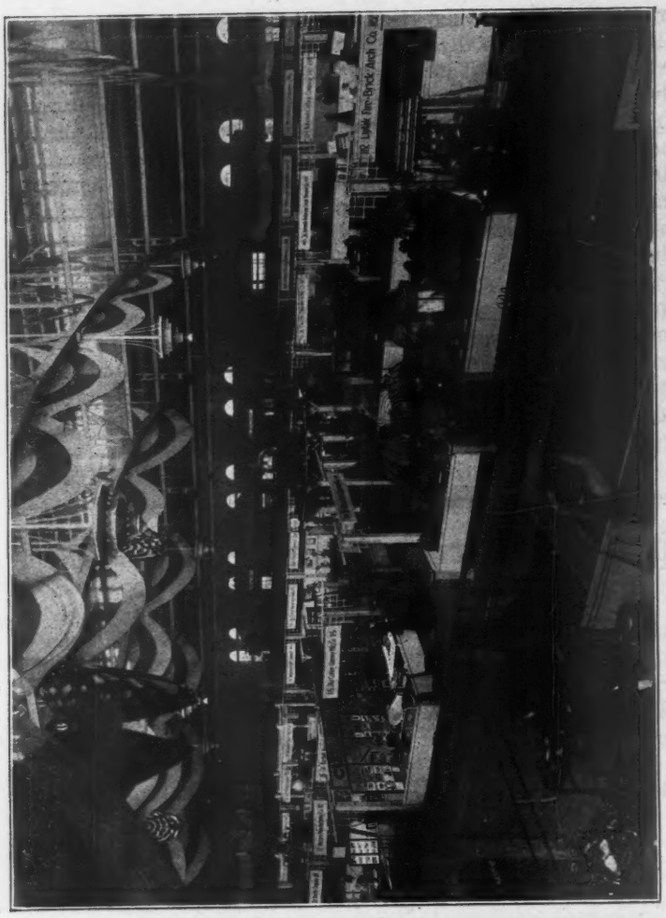
The following are some of the high spots which have come out in this discussion, classified according to: (1) Users of motors; (2) builders of motors; (3) builders of bearings.

A relatively small class of the users of motors have used ball or roller bearings in motors. A vast majority of this class are very enthusiastic over the results obtained. They have had some bearing failures, but have been able to satisfactorily explain these failures and rather definitely fix the causes as follows: (1) Improper mounting; (2) improper size of bearing; (3) grounded armatures. With ball bearings a smaller number of armatures are grounded in a given length of time. (4) Improper lubrication, which may be divided into: (a) Improper lubricant; (b) lack of sufficient quantity of the proper lubricant.

Many users believe in ball or roller bearings but have hesitated to put them into service, because of insufficient information, and because the motor builder does not urge their use and who, when asked for a quotation, makes the price almost prohibitively high. This class of user in general is merely waiting for the first class to say more about their experiences and for the motor builders to come out with a definite recommendation for the roller or ball bearing.

A third relatively small class do not believe in ball or roller bearings, primarily because they feel that the sleeve bearing, as now in general use, is satisfactory and meets the needs of their particular industry. As a whole, this class is using motors on relatively easy work or else does not know the real causes of its motor failures.

Among the motor builders we have three classes: (1) Those who have used ball bearings extensively. These builders usually report good results, and where a standardized method of mounting has been worked out do not quote excessively high prices for motors equipped with ball bearings when compared with their prices for sleeve bearing motors. (2) This class of motor builders includes those who believe that ball or roller bearings can be successfully applied, and are entirely willing to furnish motors equipped with these bearings, provided the motor user will pay the bill. The bill is high because no standardized method of mounting has been worked out. (3) We have the motor builder who believes that motors are good enough with the present type sleeve bearing, and who furthermore believes that if bearing improvements are necessary, such improvements can be made in the sleeve bearing.

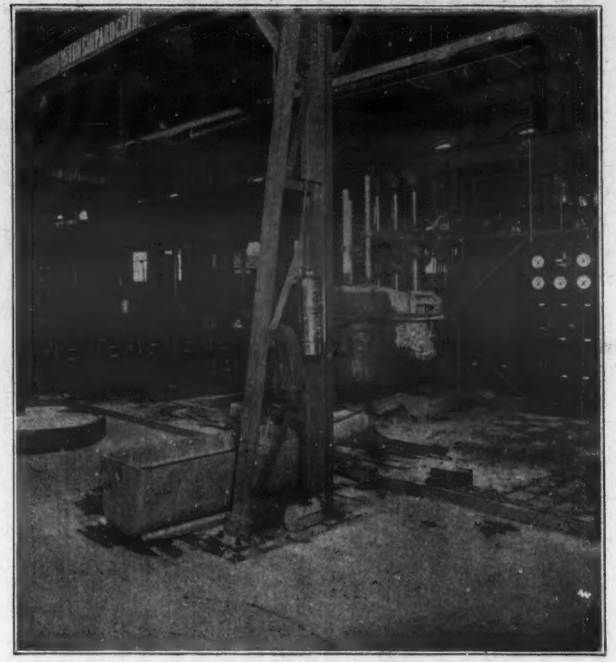


GENERAL ELECTRIC COMPANY

The Steel Mill Equipment Display

At Buffalo (N.Y.) Convention of Association of Iron and Steel Electrical Engineers

THE million-dollar exposition of steel mill equipment at Buffalo, N. Y., September 24 to 28, is shown from four angles on the opposite page. Below, in the lower center and lower right photographs, are shown two sections of the electrified foundry which was in operation during the convention. Molding, melting, pouring, cleaning, grinding and handling operations were demonstrated. A wide variety of equipment used in the iron and steel industry was on exhibition.



His arguments against ball bearings include the argument of excessive cost of changing existing designs, with the cost and difficulty of doing the accurate machine work necessary in mounting the ball or roller bearings.

With the builders of bearings the ball bearing has been standardized internationally. This standardization includes three general weights of bearings, the light, medium and heavy. Each of these three general classifications includes many varieties. This standardization does not include the size of ball or shape of race, but the outside diameter of the outer race and the inside diameter of the inner race; in other words, the international standards make the mounting dimensions of ball bearings entirely interchangeable from one manufacturer to another.

Roller bearings of the large diameter, short length, solid type have been somewhat standardized along the same line. There are several lines of roller bearings on the market which are interchangeable with the medium series of ball bearings. Ball or roller bearings properly mounted are good or bad, depending upon the accuracy of the grinding. The use of ball and roller bearings is constantly increasing, consequently the manufacturing facilities have been constantly increasing so that the cost of the finished bearing has been and should continue to gradually decrease.

Roller bearings of small diameter and great length do not line up with the ball bearings as well as the roller bearing of large diameter and short length. Owing to the marked difference between this type of bearing and the ball bearing, it will very likely be found necessary to make a separate standardization. Within any series of bearings there lies a wide choice of design ranging from the shallow flat race with a small number of large diameter balls to the very deep race with a large number of small diameter balls. These various designs have their particular points of advantage which should be taken into consideration by the user as well as the builder of motors with the liberal co-operation of the bearing engineer.

The minutes of the joint meeting of the Bearing Committee, A. I. & S. E. E. and the Power Club contain the following recommendations:

1. It is desirable to standardize bearings as quickly as possible so that motor users may install roller or ball bearings in existing motors and use sizes which will line up with standards to be used by motor builders in the future.

2. It was considered desirable and practical to standardize on ball-bearing sizes that will be interchangeable with roller-bearing sizes so far as outside and inside diameter is concerned. Roller bearings in this discussion being limited to the solid roller type, it was pointed out that while a roller bearing and ball bearing of the same inside and outside dimensions would be interchangeable from a mounting standpoint, the roller bearing would almost invariably be capable of carrying a somewhat heavier load.

3. It was considered advisable to adopt the standard ball-bearing sizes of the 300 series, and that the roller bearings be made to conform to these sizes so far as inside and outside dimensions are concerned.

4. That the number of sizes standardized upon for motors be limited to the smallest number practical so as to reduce the number of spare bearings necessary to stock for protection against breakdowns.

5. That no attempt be made to standardize on any particular size of bearing for a given frame size of motor of any given horsepower rating or speed but that the selection be left in the hands of the designing engineers.

Motor-Operated Centrifugal Pumps

By B. A. CORNWELL,

Electrical Engineer, Carnegie Steel Company, Youngstown, Ohio.

IN THE steel industry, one of the most important factors in maintaining and increasing production is the efficiency and the reliability of the water supply system, which we feel should be electrically driven. Centrifugal pumps are especially suited for handling large quantities of water quickly and in many plants this type of pump has been adopted for supplying water under low heads for blast furnaces, condensers, cooling water systems, etc. The velocity imparted to the water by the impeller determines the head and the following general laws govern the action of all centrifugal pumps: (1) The head varies as the square of the speed; (2) the quantity of water pumped varies directly as the speed; (3) the power required to drive the pump varies as the cube of the speed.

A centrifugal pump is the simplest type of pump, hence the first cost and maintenance is less than for other types. This type of pump does not require a licensed engineer, neither does it have steam line losses while idle as with a steam pump. There is no reciprocating motion—consequently the discharge is free from pulsations, avoiding the necessity of air chambers. The entire absence of valves and plungers allows the pump to pass solids as found in sewage which would interfere with the successful operation of a pump dependent upon valves. With electrically-driven centrifugal pumps there is the possibility of remote control.

Due to the construction and the characteristics of this type of pump, the starting requirements are not heavy, as the starting torque rarely ever exceeds 30 per cent of the full load torque. With a centrifugal pump, decreasing the head pumped against will increase the load on the motor. The design of this type of pump is such that it will raise considerably more than 4/3 the amount of water at a 30-ft. head than it would at 40-ft. head, with the result that the motor is greatly overloaded. In this respect, the centrifugal pump is exactly opposite to the plunger or reciprocating pump which being positive in its action, increases its load with the increase of head and *vice versa*.

With the discharge valve closed the efficiency is zero, since no useful work is being done. The horsepower required under this condition is consumed in friction and dissipates itself as heat with the result that an electrically driven pump of this type cannot be operated with its discharge valve closed for more than 15 or 20 min. without overheating.

Interesting data were recently obtained from tests made on a large centrifugal pump in a steel mill. In order to make a comparison of the cost of the electric power consumed by this 1,000-hp., motor-driven pump with a steam turbine driving this same pump on the same service, we must first get the operating cost per kw.-hr. at the motor and the cost per pound of steam at the supposed turbine. The average cost per kw.-hr.

for the electric power in the plant where this pump is operating is $0.00355—the generating station being blast furnace gas engines.

Allowing a 2 per cent loss in the 6,600-volt line to the motor and taking the station cost of power at $0.00355 per kw.-hr., gives an average cost of power at the motor of $0.0036 per kw.-hr. From the results of tests this pump has its maximum efficiency at 725 r.p.m. when delivering water at the rate of 30,000,000 gal. per day against a head of 163 ft. Under these conditions the input to the motor was 828 kw. The cost per hour equals 828 × $0.0036 equals $2.98 for electric power when delivering water at rate of 1,250,000 gal. per hr., or the cost of pumping 1,000 gal. of water per hr. will be 2.98÷1250 which equals $0.00238.

The operating cost for steam power delivered to a supposed turbine driving this same pump on the same service is, as closely as may be estimated, $0.00288. In case the electric power is produced by a steam turbo-generator, the operating cost of the electric power to the motor driven pump will be slightly higher. In case lower pressure saturated steam is used to operate the turbine driven pump, or if a good vacuum cannot be maintained the operating cost of the steam driven pump will increase greatly. The operating cost of the direct acting steam pump varies from 3½ to as high as 15 times that of the motor driven centrifugal pump.

The comparative initial costs of the 1,000-hp. electric motor and the turbine driven installations including starters or condensers and auxiliaries, but exclusive of buildings, wiring or piping, which would vary greatly depending upon local conditions, is as follows:

Induction motor driving pumping unit	$15,400
Synchronous motor driving pumping unit	15,800
Steam turbine driving pumping unit	38,000

However, in this comparison, the motor driving the motor driven pumping unit should be charged with its part of the power station costs exclusive of boilers in case turbo-generators are used, or in case power is produced by gas engine driven generators, the motor driven unit should be charged with its proportional part of the power station costs and the turbine driven pump with its part of the boiler house cost. This would work out about as follows:

A 15,000 kw. turbine generating station exclusive of boiler house would cost approximately $53 per kw. of capacity.

A 21,000 kw. gas engine driven generating station would cost approximately $190 per kw. of capacity.

A boiler house for 10,000 boiler hp. output would cost approximately $2,600 per 1,000 lbs. of steam per hr. capacity.

All of the above figures have been estimated and do not include any spare equipment.

Investigations have been made showing a comparison between a totally electrically driven steel mill with modern equipment and a steam driven plant using the same conditions of fuel costs, etc., which show that the electrically driven plant has the advantage of from $2 to $2.50 per ton of material shipped when compared to the totally steam driven plant.

With centrifugal pumps there is a definite relationship between the capacity and the head against which the pump has to operate. It is a velocity pump and in many instances, even those who have used a pump of this type, do not fully appreciate how sensitive it is to speed changes.

Within the past few years there has been a decided tendency toward higher speeds in the design of centrifugal pumps. High speed is desired because it reduces the number of stages required for a given capacity and consequently the first cost is less; furthermore higher speeds on pumps give higher efficiencies.

In most direct current installations a shunt wound motor is used. When the equipment is to work under a varying head and capacity it is possible in many instances to obtain the proper speed variation by means of the field rheostat—an increase of about 15 per cent can be obtained in this manner. The pump must be designed so that the desired capacity and maximum head are obtained at the maximum motor speed, otherwise there would be a possibility of overloading the motor to the danger point.

The great majority of installations make use of an alternating-current motor. Where constant speed is desired and where the inrush of current at starting is not detrimental, a squirrel cage motor may be used. In most steel plants the heavy starting current is not desired and in such cases a wound rotor or slip ring motor is used. The choice of the type of motor depends upon the starting conditions and the capacity of the generating station supplying power.

Synchronous motors are used in many instances where the power factor is low. With the discharge valve closed, the pump primed, and operating at normal speed, the motor must develop a pull-in torque of approximately 40 to 50 per cent of full load torque in order that it may come up to synchronism. The chief advantages of using synchronous motors for driving centrifugal pumps is in the power factor correction. The pumping load is ideal for this, inasmuch as the pump load is usually steady and constant.

In some installations using synchronous motors for driving centrifugal pumps a magnetic clutch is used between the motor and the pump. When the pump is not needed the clutch may be disengaged and the motor allowed to run idle as a synchronous condenser to raise the power factor of the system. From the standpoint of safety, automatic control should be used in starting up all synchronous motors driving centrifugal pumps.

There is another type of synchronous motor now on the market which is called a "super-synchronous" motor with a revolving stator and brake mechanism. This motor is capable of exerting a starting and accelerating effort in excess of the rated full running torque of the motor. By taking advantage of this characteristic, heavy starting torque is secured mechanically by the addition of this brake mechanism. This type of motor is well suited for driving fans and centrifugal pumps starting under load, and could be used to advantage in many other steel mill applications.

Where steam pumping equipments have been entirely replaced by electrically-driven outfits the efficiency and the operating costs have been greatly improved. However, in connection with electrically driven pumping stations, steam driven pumps in many cases are necessary to insure a continuous supply of water in case of failure of the electric power. It is generally conceded, that where electric power is available, there is no satisfactory comparison between the electric motor and gas or steam engine drive for centrifugal pumps. The first cost, maintenance and attendance are considerably less, the simplicity and the reliability much superior and the power cost ranges from 25 to 50 per cent less, as has been demonstrated from actual tests.

System in Electrical Division Work

By P. T. VANDERWAART

Electrical Engineer, The New Jersey Zinc Co., Palmerton, Pa.

IN THIS paper the author presented a discussion of present practice in handling routine engineering work, such as the preparation of specifications, estimates, plans, and lists of materials for construction, and the recording of location, inter-relation and duty of apparatus. The following abstract gives the main points taken up with comments on practice and experience by the author.

Supply House Material should be used whenever possible, even to the extent of sacrificing a minor feature in design. The layout engineer must have before him an up-to-date list of the standard supplies in stock. This list gives a complete specification of each item, the standard package quantity, the minimum stock quantity tolerated, the unit cost plus loading, and space for dates and remarks. The original forms and entries, excepting unit costs and dates, are made on tracing cloth and white prints are issued to interested parties, such as the purchasing department, supply house, engineering division and foremen of construction and operation. An estimator is particularly interested in the unit costs, which he keeps up to date by pencil notations and revisions on his set of white prints.

A considerable amount of detail work on estimates and plans can be saved by the adoption of *Construction Standards*. These standards are the logical place to list the required sizes of screws or bolts for different fittings. For example, a standard on "conduit clamps" gives the proper assembly of clamp, screw, and expansion shield for each size of conduit.

Liberal reference is made to standards on specifications and estimates. On the *Estimate Sheet*, for instance, the requisite number of lighting outlets 1-X-343, is set down under material, the unit labor and material prices plus loading copied from the book of standards, and the totals carried out. Materials not included in the unit cost of the standard are similarly taken from the supply house material sheet.

The *Lists of Material* for drawings are typed and filed separately under construction account numbers, with proper cross references. Sufficient copies are made for purchasing, supplies, construction and engineering files.

The *Job Progress Sheet* prevents the overlooking of any part of any job. As soon as it is decided to go ahead with a job, the necessary items of work and apparatus to be purchased are listed. Promised dates for completion can be entered under remarks. Actual date of completion is noted in proper column. The sheet shown is a check suitable only for the drafting column. The general engineer on the job will keep a more complete check on delivery of materials and construction progress.

Systematic load records are every bit as important as apparatus records. *Feeder Load Records* are kept in a loose leaf file. Each sheet shows for a particular feeder the connected load, kw-hr, and average and maximum amperes for stated time periods. Space is provided for recording voltage observations and power factor and load factor calculations. Fifty-two entries can be made on each page. If the time periods are weeks, the complete load history for a year is recorded on a single page in convenient form for reference.

The records are posted from weekly reports of watt-hour meter readings and *graphic charts*. Each feeder has a watt-hour meter and a graphic ammeter, and each station bus has a graphic voltmeter. The back of each chart is stamped to provide a place for the meter man to note down the feeder name and number, time started and time stopped, respective watt-hour readings, the ammeter constant, and the watt-hour meter constant.

These records include total power house and substation loads as well as loads in the several feeders from the substations. Accurate diversity factors are therefore easily and quickly calculated.

Systematic work is nowhere more important than in tests on operating apparatus. For one reason or another information on power requirements or production data is desired from time to time by different individuals, and each will usually emphasize the feature in which he is particularly interested to the exclusion of other desirable or even necessary data to make a complete report.

Many plants are making motor load surveys which record nothing more than the power input to the motor, with possibly some comments on the load cycle as shown on a graphic chart. Correlative information on the driven machine and its output should be taken.

PAGE 10 REVISION

SUPPLY HOUSE MATERIAL	STD PKG.	MIN. STOCK QUANT.	UNIT COST +LOAD	DATE	REMARKS
Pin, 1-1/2" x 9" Std. Locust, Wood	250	50			
" Pierce, #934, Hot Galv.	150	15			
" Leg without thimble Hot Galv. 3/4"x6-1/2" Stud K.Pins Cat.9008	50	25			
Plate, Double Hinge Lift cover, Hubbell #8580	10	10			
Plug, Alex Plural Socket, W. P. List #28		5			
Plug, Swivel Attachment Benjamin #903	10	10			
Plug, conn. Cannon, Attachment, Hubbell #8618	10	10			
Plug, Cap, Cannon, Attachment, Hubbell #8687	50	10			
Receptacle, Paiste Fielding Paiste #80728	10	10			
Receptacle, Plug, Flush Hubbell #8579	10	10			
Reflector, Ivanhoe, RED-60	50	10			
" " RED-75	40	10			
" " RED-100	25	5			
" " RED-100	5	10			
Salt, Yeagare Soldering - 1/8 lb. Bottles		8 Lbs.			
Screws, Mach. Fillister Head Hot Galv. #14-20 x 1/2"	500	50			
" " " " " #12-18 x 3/4"	500	50			
" Lag, Potter Drive, Hot Galv, 1/2" x 3-1/2"	100	50			
" Wood, R. H. Hot Galv. #12 x 1-1/4"	200	100			
" " " " " #14 x 1-1/4"	500	100			
" " " " " #16 x 1-1/2"	100	50			
" " " " " #24 x 2"	50	25			
" " " " " #30 x 2"	50	25			

Lists of standard supplies are made on these forms which show at a glance the minimum quantity carried in stock, standard package quantity, and so on.

In and Around the Steel Plant

Electric Furnace Phenomena

By EDWARD T. MOORE

Electrical Engineer, Halcomb Steel Co., Syracuse, N. Y., and Consulting Engineer, Crucible Steel Co. of America, New York.

INVESTIGATIONS were started in July, 1922, but because of the large amount of data secured it was impossible to properly analyze it and prepare a paper for the 1922 convention. This work has since been done and was presented as the Electric Furnace Committee's 1923 report.

The tests were conducted at the works of the Halcomb Steel Company, Syracuse, N. Y., on one of the company's six-ton Heroult furnaces. This furnace is one of the counterweight type and has connected to it three 500-kva. single-phase, self-cooled, core-type transformers.

Results obtained in the tests indicated that the maximum difference between phases was 340 kw., or 21 per cent of the connected load.

In the short-circuit test the maximum short-circuit value was found to be 3.66 times normal. This checks remarkably closely with previous tests where the highest value was 3.61 times normal.

From the readings taken the following average power factors were secured: melting period, 90 per cent; refining period, 88 per cent; for entire heat, 89 per cent. Therefore, an electric furnace such as the one under test is a very desirable load from a power factor standpoint and will always operate at a higher power factor than induction motors.

Other results and observations are: that at heavy loads the power factor goes up; that there is no large disturbance of power services on the furnace circuit beyond a momentary swing in voltage when the furnace load comes on. These voltage variations were of only average magnitude—not over 4 per cent. The load taken by the furnace and the amount of reactance in the circuit determine surges or fluctuations. Short circuits, such as occur in a furnace when charging cold scrap, do not generally take place across all phases at once, although at times all phases may be shortened. Some unbalancing occurs but it is not sufficient to cause the slightest trouble on a power system of adequate capacity.

A relatively high speed of electrode travel was found desirable and resulted in re-establishing the arc, after it had been extinguished by the fusing of a portion of the scrap, very much sooner than with slower electrode travel.

When integrating watthour meters are connected to the primary side of the transformers supplying the furnaces, these meters are accurate within commercial limits.

When meters are connected to the secondary side there is no doubt that serious errors in registration would result, due to presence of direct current caused by rectification in arc.

Electric Transportation

By F. O. SCHNURE

Electrical Engineer, Bethlehem Steel Co., Sparrows Point, Md.

YARD haulage and transportation within a steel plant, probably represents the largest variety, if not the most severe work of any industrial haulage. Yard electrification as a factor in bringing lower haulage costs, should be of prime interest to the steel industry. Present steam practice, and electric in other fields, would indicate that two sizes of locomotives are required for steel plant service and that these should average about 40 and 80 tons per unit. This classification makes it very simple to standardize on the 40-ton unit, the control on which should be so arranged that two such units could be operated in multiple by one man on the heavier service.

In a plant employing twenty-five steam locomotives, ranging from 50 to 75 tons capacity, it is altogether likely that twenty electrical units would perform the same work. Hostler service, not required on the electric unit, and boiler repairs usually keep several steam units out of service every day. The repairs on an electric locomotive comparable to boiler repairs would be the practically negligible time to change a motor. The control on the electric locomotive should be electro-pneumatic to avoid low voltage troubles and should be arranged to be operated from opposite sides of the cab.

The third rail lends itself more readily to steel plant yard electrification than an overhead trolley, because it does not interfere with the work of locomotive cranes, and it is better able to handle the heavy operation at low voltage. There are two kinds of third rail systems, one the top contact and the other the bottom contact system. For yard work where switchmen and plant employes may not be denied free and safe passage over all portions of the yard, the bottom contact is preferable.

Electrification of the Foundry

By LEONARD W. EGAN

Special Engineer, Ohio Steel Foundry Company, Lima, Ohio

The discussion of the various types of electrical apparatus used in the foundry was divided into seven or eight general subjects: (1) Electric molding machines. (2) Sand handling systems. (3) Electric furnaces. (4) Cranes. (5) Purchased power. (6) Electric welding. (7) Safety. (8) Air and electric hoists.

Adaption of mechanical molding by use of molding machines permits the use of a cruder grade of labor in about 80 per cent of the work of making molds.

The two outstanding features in the electrification of machine molding, which have been brought out in the last few years, are (1) the roll-over jolt Pattern Draw Machine with electrically operated pattern draw and roll-over, equipped with electrically operated runout car, and (2) the Sand Slinger.

The Sand Slinger is a molding machine which employs a radically different principle in its operation than that of any other type in existing practice. The sand is pitched or thrown into the mold at high velocity, which rams or packs it around the pattern.

A complete, well-built and motor-operated sand handling and conditioning system is needed in every foundry of any importance. The work entails a number of operations and there is a number of ways in which this work can be done, which will vary in the general arrangement of each installation.

The electric annealing and heat-treating furnace has had a considerable development in the past five or six years, especially the treating furnace. It has a high degree of flexibility and where quantity production of a uniform type is possible, it offers unlimited possibilities in heat treatment.

In the melting of non-ferrous metals such as copper, bronze, brass, aluminum, zinc and the multitude of special metals and alloys, including cupro-nickel metals, bearing metals, white metals, etc., the electric furnace is finding a broader application every day.

There are four principal types of furnaces in use in this branch of melting: The open arc, the muffled or smothered arc, the resistance and the induction furnace

The electrically-heated core oven is coming into more general use every day, not only because of the vast improvement in the quality of the cores, but where the cores are irregular in shape, and of the smaller variety, baking can be done cheaper and faster.

The process of electric welding is being used more and more in the foundry for welding castings. Both the metallic electrode and the graphite electrode processes are used, depending on the requirements and nature of the work.

Air cylinder hoists are used to a large extent in the foundry industry, chiefly in conjunction with hand-moved jib cranes. Trouble with the electric hoist in the past has been due to inability of the hoist to withstand the abuse received. With the advent of a more rugged type, the electric hoist will be more likely to supplant the air hoist which is now in general use.

Blast Furnace Skip Hoists

By A. C. CUMMINS

Electrical Superintendent, Carnegie Steel Co., Duquesne, Pa.

and

A. R. LEAVITT

Electrical Engineering Dept., Carnegie Steel Co., Duquesne, Pa.

IN MAKING a selection of the correct type of equipment to be used for a given hoisting problem, the electrical engineer must carefully weigh the advantageous features of each. This paper called attention to the principal features claimed for each of the four types of electrical apparatus for single-bucket blast furnace skip hoists, enumerating the claims made for each variety of equipment and also their limitations, and presented data secured while checking over the actual performance of a number of hoists to corroborate the various points of superiority which each type is said to possess. The four types of drive discussed were: (1) Single motor, direct current; (2) double motor direct current; (3) single motor alternating current; (4) Ward-Leonard or variable-voltage drive using either alternating or direct current.

A part of this paper which covers a discussion of the effect of various types of inclines upon handling of material is given in the department "Handling Materials" which begins in this issue on page 513.

Main Points in the Discussion at Buffalo Convention

WHILE most of the papers presented dealt with practical operating conditions rather than theoretical or untried practice, the discussion brought up important points on which experience agreed or differed under the same or other conditions. These practical points and comments by the various speakers who discussed the papers are given briefly in what follows.

In connection with his report, F. W. Cramer, Chairman of Standardization Committee, urged that the directors of the association request the management of the large steel plants to appoint an official representative to co-operate with the standardization committee and that this committee should co-operate with the American Engineering Standards Committee. As a starting point for standardization it was suggested that holes for the holding bolts of motors be spaced in a uniform manner. Contacts for control boards were pointed out as another item that should be standardized.

In referring to the report on electrical developments, Mr. Kennedy reminded the chairman that a 5,000-hp. electric reversing mill drive was installed in 1916 at the Mark plant of the Steel & Tube Company of America, one year earlier than mentioned in the report.

As part of the report of the special bearing committee, of which D. M. Petty was chairman, fifteen standard sizes of ball and roller bearings were tentatively proposed. These were sizes 305, 306, 307, 308, 309, 310, 311, 312, 314, 315, 316, 317, 318, 320 and 322. These are for general purpose motors of 1-hp. to 100-hp. In the discussion on this subject it was pointed out that as roller bearings will carry heavier loads, except at higher speeds, than ball bearings of the same dimensions, this greatly increases the possible number of applications. Further discussion with members and with the Electric Power Club was suggested before any sizes are finally declared standard, in order to avoid the possibility of error.

Mr. Hipple of the Electric Power Club warned the members not to rush the adoption of ball and roller bearings, as they are not altogether out of the experimental stage and also because sleeve type bearings will probably be developed which will not have the troubles of the present sleeve bearings; namely, slinging oil and allowing the entrance of grit and dirt into the bearings. However, the consensus of opinion of the operators attending this session was that roller and ball bearings have advantages that will increase their use. A. C. Cummins, electrical engineer, Duquesne Works, Carnegie Steel Company, stated that burnouts on a number of motors were much less frequent after he had substituted ball bearings for sleeve bearings. In this connection he mentioned a trouble which he had experienced with ball bearings. This was that the balls were damaged by current when a motor developed an accidental ground. The balls of these bearings often were so badly overheated that their life was very short after this trouble. As a result the cost of replacing bearings sometimes overbalanced the saving in armature repairs. He mentioned, however, that there are ways in which this trouble can be removed. He is, for instance, trying out a brush which is connected to the motor frame at one end and bears on the shaft at the other end, the object being to shut off the current before it reaches and damages the bearing.

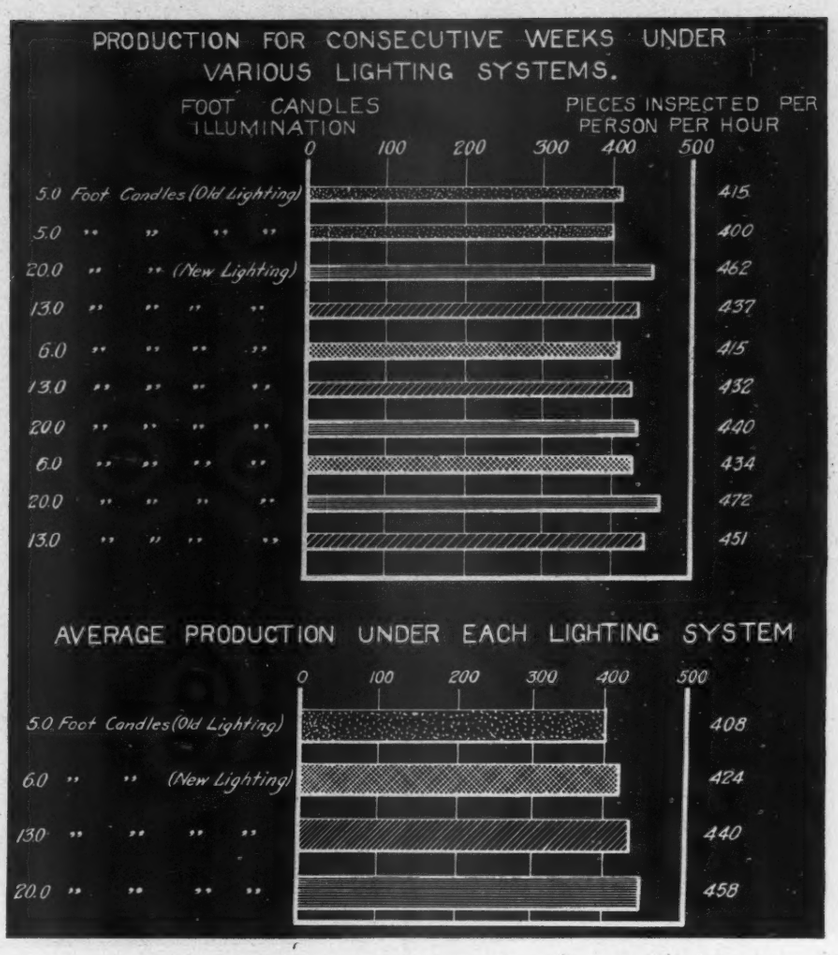
In the discussion on motor-operated centrifugal pumps, several speakers agreed with the author of the paper that electrical drives are more economical than steam. An important advantage of the electric drive is the possibility of making it semi-automatic, thus eliminating the costly attendance required by steam drives. (*Continued on page 515.*)

THE RESULTS of the tests described in this article are of particular interest to industrial plant men, for they indicate in a practical way what can be accomplished by the use of higher lighting intensities where speed is an element in a manufacturing operation.

Results of Some Tests on

Relation of Lighting to Production

Showing How a 12.5 Per Cent Increase in Production Resulted from Increasing the Lighting Intensity


PRODUCTION FOR CONSECUTIVE WEEKS UNDER VARIOUS LIGHTING SYSTEMS.
FOOT CANDLES ILLUMINATION
PIECES INSPECTED PER PERSON PER HOUR
0 100 200 300 400 500
5.0 Foot Candles (Old Lighting) 415
5.0 " " " " 400
20.0 " " (New Lighting) 462
13.0 " " " " 437
6.0 " " " " 415
13.0 " " " " 432
20.0 " " " " 440
6.0 " " " " 434
20.0 " " " " 472
13.0 " " " " 451
AVERAGE PRODUCTION UNDER EACH LIGHTING SYSTEM
0 100 200 300 400 500
5.0 Foot Candles (Old Lighting) 408
6.0 " " (New Lighting) 424
13.0 " " " " 440
20.0 " " " " 458

BY D. P. HESS

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and

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THE information that follows relates to a test that was recently conducted at the Columbus (Ohio) Plant of the Timken Roller Bearing Company to establish what relationship, if any, exists between illumination and production in a factory that manufactures roller bearings. This information was presented before the Illuminating Engineering Society at its convention at Lake George, N. Y., September 24 to 28, 1923.

About fifteen per cent of all works employes of the Columbus plant are inspectors and the section chosen for the test was known as the *Green Inspection Department*. The nature of the work in this department consists of inspecting the material in the green, that is, just as it is turned out by the automatic screw machines and before heat treating. The material inspected as illustrated in Fig. 8 consists of various sizes of cups, cones and threaded cones, which are separate parts of a roller bearing.

The work is carried on in three stages: The first group of inspectors guage the material for diameter and depth; the second group inspect for defects such as chatter, tool marks, ingot breaks, thin ribs, and bad chamfer; and the third group for imperfections in the thread on the inside of the cones, bad mill, bad chamfer, and inadequate burnishing. Some of the work such as the inspection of threaded cones, ingot breaks and chatter marks requires close visual inspection, while in some of the gauging, which is done by means of indicating and limit gauges, as illustrated in Figs. 9 and 10, relatively little is required of the eyes.

The personnel of this department at the time the test was begun consisted of foreman, clerk and thirty-eight inspectors. This number varied each week, the average inspectors during the test being forty-four. Table I shows the weekly change in personnel of the department during the entire test.

The area occupied by the *Green Inspection Department* has dimensions of approximately 30x60 ft. and is located near one corner of a large one story building covering about 6 acres. (See Fig. 2.)

The lighting system in this department at the beginning of the test consisted of 6 outlets, 4 of which were equipped with 200-watt clear lamps, and 2 with 150-watt clear lamps. The 6 lamps were equipped with enameled steel reflectors and gave an average illumination of about 2 foot-candles. The distribution of light, however, due to wide and irregular spacing of the units, was uneven and caused bad shadows. Fig. 1 shows the lighting effect produced by this system.

The department is so located that it receives daylight from windows at a distance on one side and from skylights located in the saw-tooth roof construction. During the greater portion of the time throughout the first two weeks of the test, the above mentioned lighting system was used as a supplement to the natural daylight. The resulting average illumination in the test section for this period was approximately 5 foot-candles.

Fig. 1—Original lighting at the beginning of the tests showing uneven distribution and bad shadows.

The new lighting layout, Fig. 3, consisted of twenty-eight Glassteel diffusers located on 8 by 10 foot centers and mounted 12 ft. from the floor. This type of lighting unit (Fig. 4) has an enclosing globe that entirely surrounds the lamp, producing an even distribution of light with soft shadows, and a noticeable absence of objectionable specular reflection. The lighting effect obtained by the above mentioned system is shown in Fig. 5.

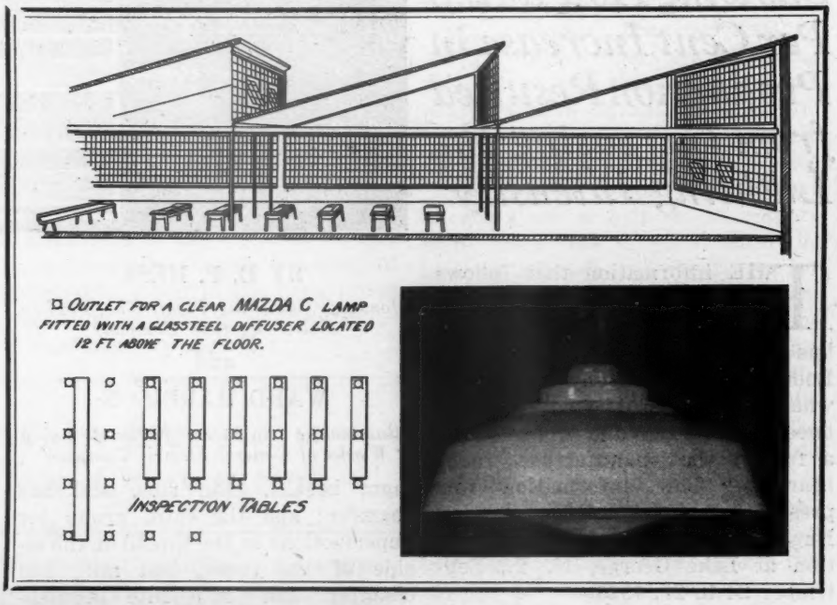
In an effort to maintain the levels of illumination under this system as uniform as possible, the skylights in the saw-tooth roof were blackened.

PROCEDURE IN THE TEST

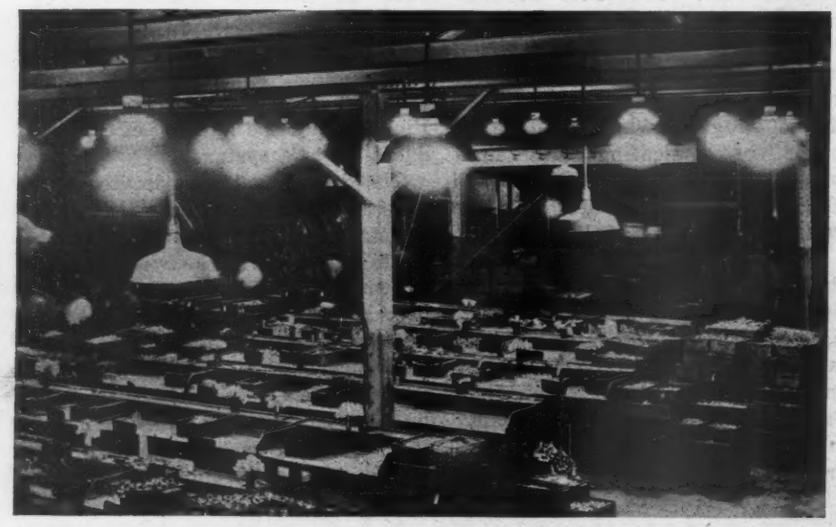
The test was planned to include investigations of the old system, a 6 foot-candle system, a 13 foot-candle system, and a 20 foot-candle system. The test weeks in each case were begun on a Thursday and ended on a Wednesday, continuing for a period of ten weeks. Due to the advancing season and much stronger daylight, it was found impossible to return to the original 5 foot-candle system obtained from the unobstructed skylight and 6 incandescent lamps. Table II gives the order of tests.

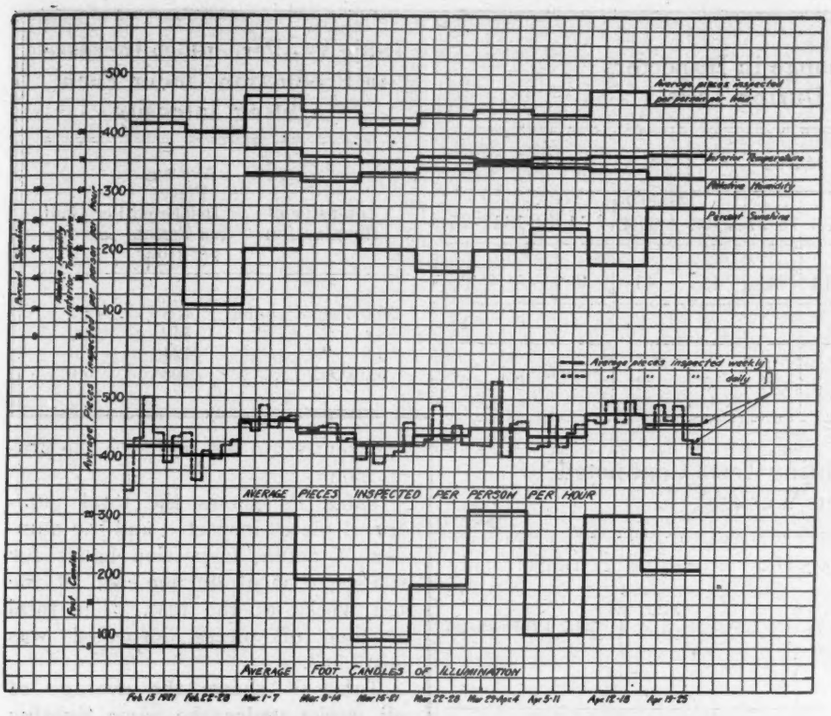
Records were available in the *Green Inspection Department* which showed the number of pieces inspected per day with the total number of actual inspection hours. Often, especially in the case of overtime, an inspector is called upon to do general work in the department, such as moving containers and cleaning up. In that event his time is not shown on the inspectors' records, but only on the time cards. If an experienced inspector is required to instruct a new worker, the experienced inspector's time does not appear in the inspection records. All employees in this department are paid on an hourly basis.

The question has often been raised as to whether atmospheric conditions materially affect the output of factory workers. In an effort to obtain data on this point wet and dry bulb thermometer readings were taken four times a day at the test area and from these the relative humidity calculated. The daily weather bureau record showing the per cent sunshine, exterior temperature, and amount of precipitation, was also tabulated.



Figs. 2, 3, 4 and 5—Sectional view of the department in which the illumination tests were conducted, together with lighting layout and reflectors used over inspection tables to secure increased illumination and lighting effect shown in the illustration below.



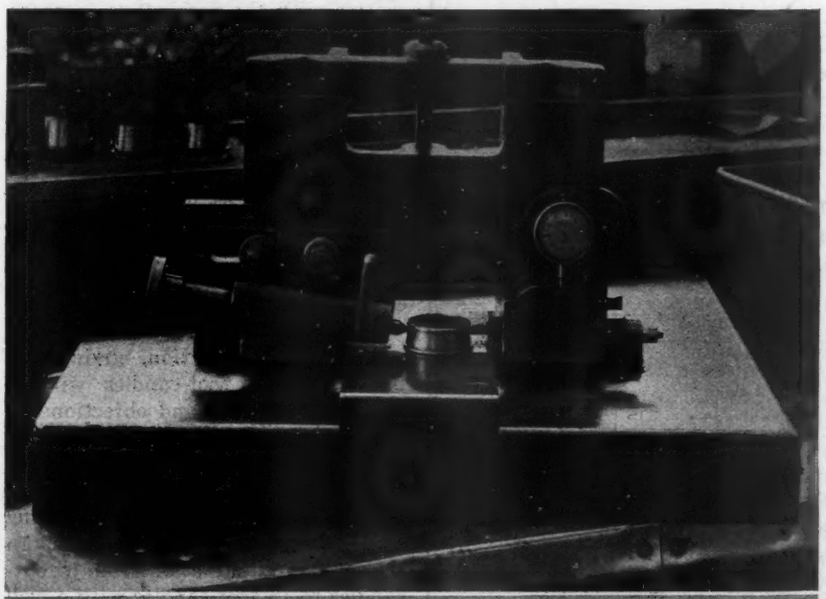


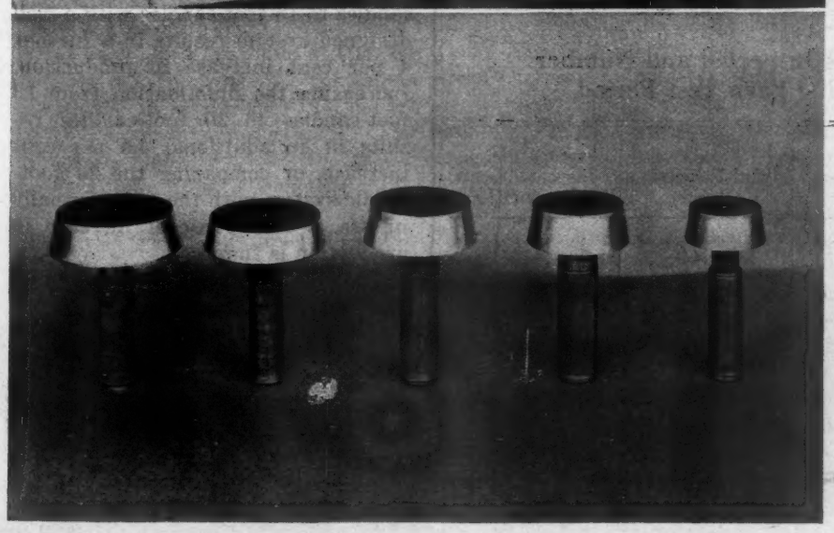
Figs. 6 and 7—Graphical presentation of production, temperature humidity and sunshine conditions during the illumination and production tests. Also daily rate of production during ten weeks. These curves show the average of the tests.

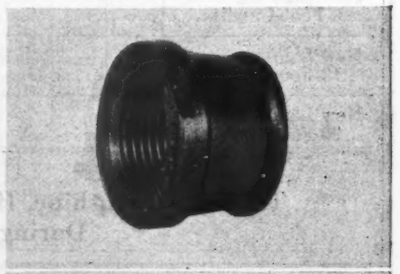
Results of the Tests

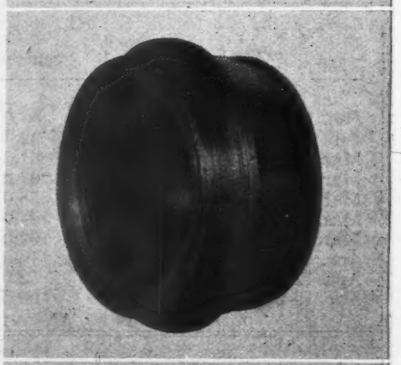
Table III and the curves of Fig. 6 show the per cent of sunshine, average weekly relative humidity and average weekly interior temperature. It will be noted that the tests were run at a season of the year when artificial heat was necessary and as a result both the interior temperature and the humidity were fairly constant. There was a considerable variation in per cent of sunshine for the several weeks but the variation

Fig. 8—Types of material inspected during the lighting tests.
Figs. 9 and 10—Indicating and limit gauges employed during the tests that do not require close visual inspection.









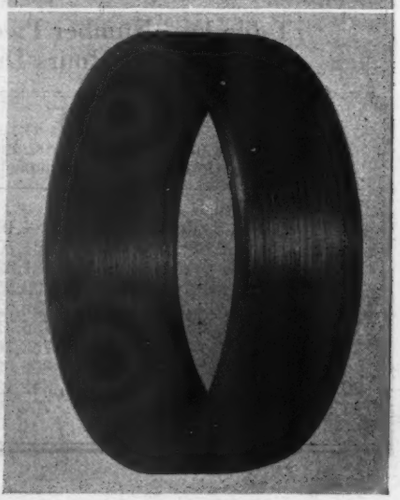


Table I—Weekly Change in Inspectors in Department During Tests

	February		March				April			
	15-21	22-28	1-7	8-14	15-21	22-28	Mar. 29 Apr. 4	5-11	12-18	19-25
Total Inspectors.....	38	48	43	43	41	45	45	46	48	43
New Inspectors Hired	8	12	7	7	1	6	5	4	6	1
Inspectors Services Discontinued.....	2	12	7	3	2	5	3	4	6	6

Table II—Order of Lighting Tests Conducted During Ten Weeks

	February		March				April			
	15-21	22-28	1-7	8-14	15-21	22-28	Mar. 29 Apr. 4	5-11	12-18	19-25
Old Lighting— 5 Foot-Candles....	X	X	.....	.....	.....	.....	.....	.....	.....	.....
New Lighting— 6 Foot-Candles....	.....	.....	.....	.....	X	.....	.....	X	.....	.....
New Lighting— 13 Foot-Candles...	.....	.....	.....	X	.....	X	.....	.....	.....	X
New Lighting— 20 Foot-Candles...	.....	.....	X	.....	.....	.....	X	.....	X	.....

Table III—Sunshine, Humidity and Temperature During the Tests

Week	Per Cent Sunshine	Relative Humidity	Interior Temperature
Feb. 15-21.....	63.0	.....	.....
Feb. 22-28.....	22.0	.....	.....
Mar. 1-7.....	61.0	66.4	74.8
Mar. 8-14.....	69.0	63.8	72.0
Mar. 15-21.....	58.0	66.5	71.0
Mar. 22-28.....	47.0	68.6	72.3
Mar. 29-Apr. 4.....	62.0	71.0	71.6
Apr. 5-11.....	76.0	70.3	72.0
Apr. 12-18.....	52.0	68.3	72.4
Apr. 19-25.....	90.0	65.5	72.7

Table IV—Number Pieces Inspected and Number Inspection Hours During Each Test Period

Intensity of Illumination	Total Pieces Inspected	Total Inspection Hours	Average Pieces Inspected per Person per Hour
5.0 F.C. (Old System)....	684,164	1,644	415
5.0 "	581,709	1,449	400
20.0 (New System)...	681,621	1,476	462
12.8 " ...	708,559	1,620	437
5.7 " ...	739,627	1,778	415
11.9 " ...	735,316	1,698	432
20.2 " ...	763,762	1,737	440
6.2 " ...	809,631	1,866	434
20.2 " ...	842,138	1,783	472
13.5 " ...	766,796	1,700	451

Table V—Percentage Increase in Production Under Each Lighting Intensity

Intensity of Illumination	Average Pieces Inspected per Person per Hour	Per Cent Increase
20.0 Foot-Candles	458	12.5
13.0 " "	440	8.0
6.0 " "	424	4.0
5.0 (Old).....	408	0.0

apparently did not influence the production.

Table IV shows the total number of pieces inspected and the number of actual inspection hours for the department during each of the ten weeks of the test. The total number of pieces inspected was 7,313,323.

Table V shows the average of all weeks under the same lighting system with the percentage increase in production.

These results are also shown graphically on page 485 and in Figs. 7 and 11. Curves of Fig. 7 also show the daily rate of production for the entire period. The tests furnish apparently conclusive proof that for the class of work carried on in the *Green Inspection Department*, the production is materially affected by the character of illumination supplied. It will be noted that a well designed system of illumination, giving approximately 6 foot-candles with a minimum of glare and objectionable specular reflection, results in an increase of 4 per cent in production over that obtained under a faulty system which gave about the same average foot-candles. Likewise, an increase in illumination from 6 foot-candles to 13 foot-candles with a well designed system results in a further 4 per cent increase in production. Increasing the illumination from 13 foot-candles to 20 foot-candles results in an additional 4.5 per cent increase, or comparing the 20 foot-candle system with the one originally in use, a 12.5 per cent increase in production is found.

The current consumed with the 20 foot-candle system amounts to 8.4 kilowatts which at a rate of $0.03 per kilowatt hour results in a cost of $0.25 per hour for current to which should be added approximately $0.07 for lamp renewals and other charges, *(Continued on page 517)*

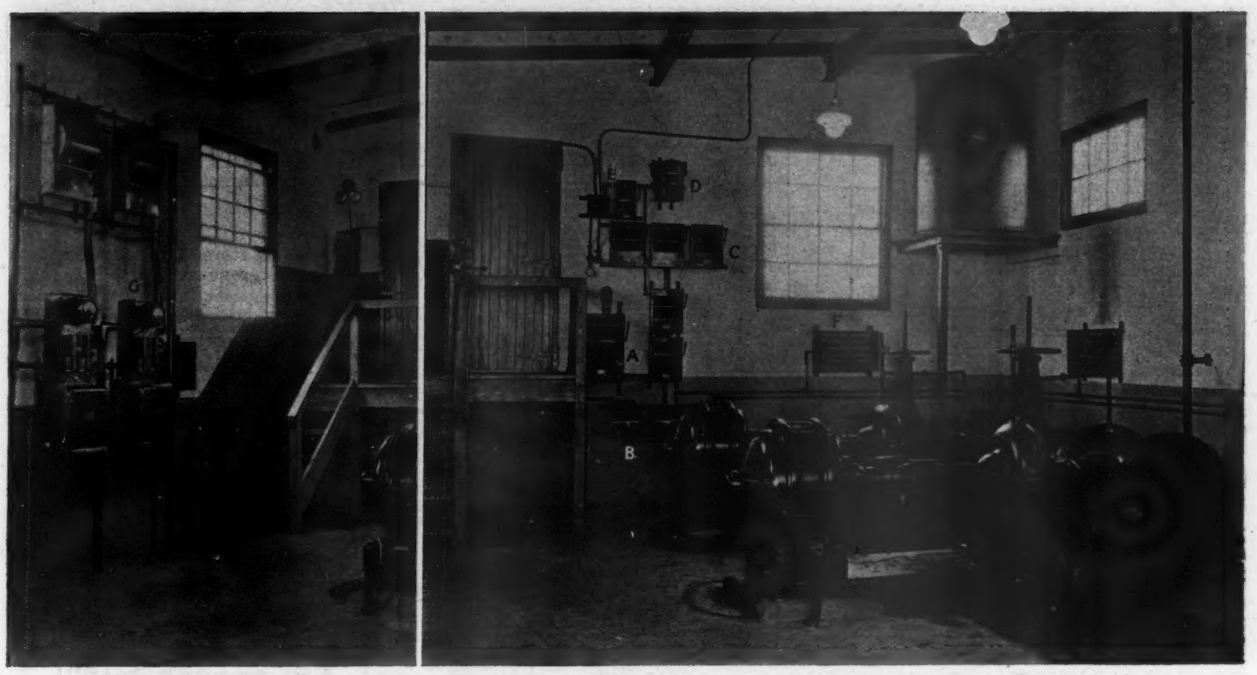


Fig. 1—Low-head pumps, motors and control equipment.
This shows the arrangement in a plant for pumping 11,000,000 gal. per day against a 50-ft. head. The motors are each rated at 75-hp., 550 volts, three-phase. At *A* is the main switch; at *B* the star-delta switches for controlling the three electric heaters such as shown at *F*, while at *C* are the disconnecting switches for the heaters. The compensators and their disconnecting switches are mounted on the pipe framework at *G*. At *D* is a 2-kw. lighting transformer feeding the lighting circuits through the distribution box at *E*.

Some Features of a

Pumping System For a Sulphite Pulp Mill

That Combines a Low-Head and a High-Head Plant Operating in Series

By H. E. STAFFORD
Electrical Engineer, Provincial Paper Mills, Ltd., Port Arthur, Ontario.

IN THIS article operating details are given for a pumping system that supplies water to a 50-ton sulphite pulp mill operated by the Provincial Paper Mills, Ltd. This system consists of two separate plants, one a low-head plant and the other a high-head plant. The capacity of each plant is around 11,000,000 gal. per day, but since the plants are practically in series, the total capacity is the capacity of one plant. The low-head plant pumps the water from a lake into a concrete tank equipped with screens, as illustrated in Fig. 4. From this tank the water is pumped to the mill by the mill-service or high-head plant.

The low-head plant is at present equipped with two single-stage centrifugal pumps operating at a 50-ft. head and each delivering 4,000 gal. per minute or 5,760,000 gal. per 24 hours at 75 per cent efficiency. The pumps are equipped with foot valves placed in the pump well, which is fed from the lake through a 48-in. main. Each pump is driven by a 75-hp., 550-volt, three-phase, 1,160 r.p.m. induction motor, direct-connected to the pump. The maximum power required for each motor is about 80 hp. and since the power is practically constant, the average power is about the same. Fig. 1 illustrates the details of the installation. Power is fed to this station from the main substation, one-third of a mile distant, over a 250,000 circ. mil cable equipped at each end with expulsion-type lightning arresters. The main disconnecting switch is shown at *A* in Fig. 1. The compensators and disconnecting switches for each motor are mounted on pipe framework as shown at *G*, making them easily accessible for repairs. Each compensator is equipped with no-voltage and overload relays and an ammeter. Provision is made for the installation of two additional pumps to take care of future mill extensions.

Electric Heating Is Used in the Pumping Plant

The station is heated by nine electric heaters, shown at *F* in Fig. 1, of a total capacity of 37½ kw. Six of these heaters are rated 5 kw. each and three at 2½ kw. each. The heaters are made up of 110-volt space heaters, mounted on angle-iron supports and covered with mesh wire covers. The heaters are connected five in series on 550-volts, three phase, and may be connected in either star or delta, to give two heats with balanced currents in each phase. The fuses and disconnects for the heaters are shown at *C*, while the star-delta switches are shown at *B*, Fig. 1. The wiring diagram for the heating layout is shown in Fig. 3. The building is of concrete construction, 41 ft. long, 21 ft. wide and 14 ft. high, with two doors and eight 4-ft. by 4-ft. windows. The temperature goes as low as 45 deg. below zero in this climate, so that sufficient heating for this temperature had to be provided. In severe weather, 25 deg. to 45 deg. below zero, the full heat or delta connection is used,

while for temperatures around freezing, the low-heat star connection is used. The heat requirements were figured from the formula:

$$\text{Watts}=5A+50a+VK.$$

where A=area in sq. ft. of all walls and ceiling, with area of windows deducted.
a=area of windows, sq. ft.
V=cubic feet of air space in building.
K=a constant depending on the outside temperature.

Values of K are: 1.5 for temperatures above 20 deg. below zero; 1.0 for temperatures between zero and 20 deg. below, and 0.5 for temperatures from zero to 10 deg. above zero.

EXAMPLE—Total area of walls and ceiling=1,148+588+861=2,597 sq. ft.
The total area of the windows—8×4×4=128 sq. ft.
Area of walls less windows=2,597—128=2,469 sq. ft.
Cu. ft. of air space=12,054 cu. ft.
K=1.5.
Total watts=(2,469×5)+(128×50)+(12,054×1.5)=36,831 watts or 36.8 kw.

The low-head station lighting consists of four 100-watt units equipped with eye diffusers, spaced on 10-ft. centers. These are supplied by the 2-kw., 550/110-volt transformer, *D*. The distribution panel is at *E*.

Water is delivered from the low-head station through a 30-in. main to the tank before mentioned, which is shown at *D* in Fig. 2. The water runs into a head box and over a screen, as the water for mill purposes has to be free from dirt. The layout of the tank, screen, head box and overflow is shown in Fig. 4, while the pump and motor installation is shown in Fig. 2. The station is equipped with two 120-ft.-head, single-stage pumps, with a capacity of 4,000 gal. per minute each or 5,760,000 gal. per 24 hours, at 74 per cent efficiency.

Each pump is driven by a 175-hp., 550-volt, three-phase, 1,160-r.p.m. induction motor direct-connected to the pump. The maximum power required for each motor is 190 hp., while the average power is practically constant at 160 hp. This station is fed from the main sub-station by a line of 400,000 circ. mil cable. The main disconnecting switch is shown at *A*, while the disconnects for each motor are shown at *C*. Box *B* contains the current transformers for the ammeters.

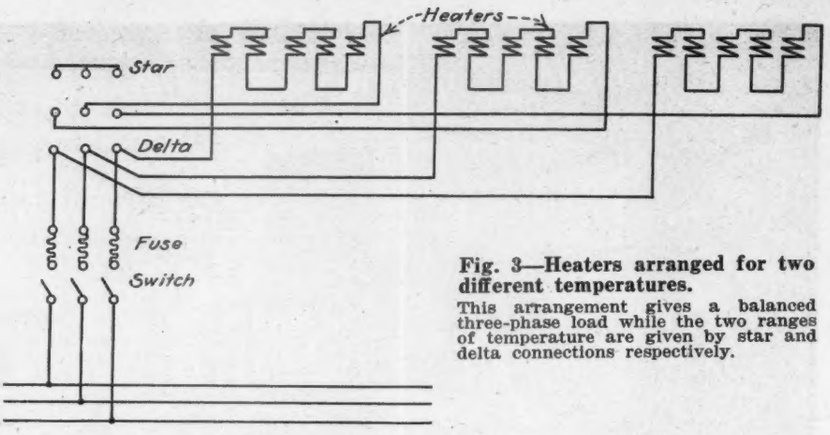


Fig. 3—Heaters arranged for two different temperatures.
This arrangement gives a balanced three-phase load while the two ranges of temperature are given by star and delta connections respectively.

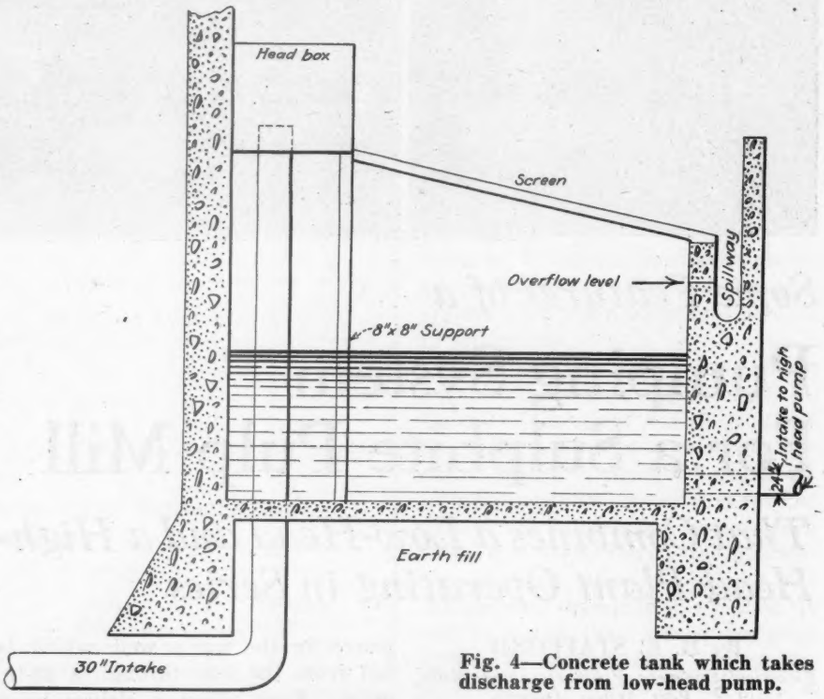


Fig. 4—Concrete tank which takes discharge from low-head pump.

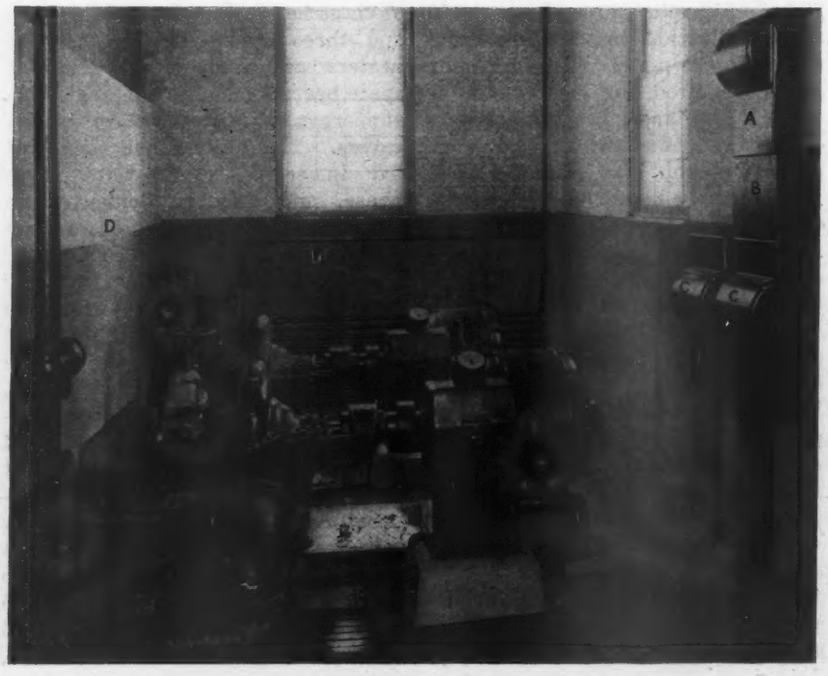


Fig. 2—A pumping room for delivering 11,000,000 gal. per day at 120-ft. head.
Each of the driving motors is rated at 175-hp., 550 volts, three-phase. The main disconnecting switch is at *A*, the motor disconnects at *C* and the compensators are pedestal-mounted near the motors. An ammeter on top of each compensator helps in starting and in operation. The current transformers are located inside of box *B*.

OF COURSE if you have a diagram when winding a motor, you can follow it, but when a diagram is not available, to know how to make one to fit a particular case is worth a good deal. Furthermore, a knowledge of the principles of winding diagrams will enable you to tell what kind of a winding has been used on a certain motor and to check over that winding to determine if it is correct. Information of this sort is given in this series of articles. The present one covers three-phase induction motors. The article in the September issue covered single- and two-phase windings.

Steps in Laying Out and

Checking Up Three-Phase Diagrams

When Using Short and Long Jumpers with Star, Delta and Other Connections

BY A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company

THIS article gives details of methods for checking the windings of three-phase induction motors and for constructing diagrams to be followed in windings. The explanations cover the short and long types of jumpers for series and parallel windings with both star and delta connections. Laying out the diagrams is explained both for the developed type of diagram which shows all the coils of a winding and for the simpler single-line type of diagram which shows only the groups of coils. Similar information for single-phase and two-phase windings appeared in the September issue of INDUSTRIAL ENGINEER. In a later issue, special kinds of windings will be explained, as two-speed windings, star-delta connections, consequent-poles, and so on. To complete the information a later article will tell just how the various connections are made on an actual stator, giving practical directions for stubbing, connecting jumpers, insulating leads and taps, and so on.

PRINCIPLES INVOLVED IN THREE-PHASE WINDINGS

In a three-phase winding a 120-electrical degree relation must be maintained between the phases. At the same time modern motors, however, are so arranged that the coils are placed only 60 deg. apart. This is a fact that is hard to understand and gives a chance for mistakes. This relation will be explained fully after the principle of the three-phase machine is described.

In Fig. 1 is shown a simplified three-phase generator. In this generator there are three conductors placed 120 electrical and 120 mechanical degrees apart. Each one of these conductors generates a single-phase voltage which alternates from zero to a maximum, then back through zero to a maximum in the negative direction, finally returning to zero. This is explained more fully in a diagram on page 440 of the September issue of INDUSTRIAL ENGINEER. The three single-phase voltages follow each other in sequence. For instance, in position 1 the voltage in conductor *A* is zero while that in *B* has a positive value and that in *C* has a negative value. In position 2, when all of the conductors have advanced 15 degrees, *A* has a positive voltage which is increasing, *B* has a positive voltage which is decreasing and *C* has a negative voltage which is increasing in the negative direction. These conditions hold until position 3 is reached, when *C* is at its maximum in the negative condition. From this time *C* begins

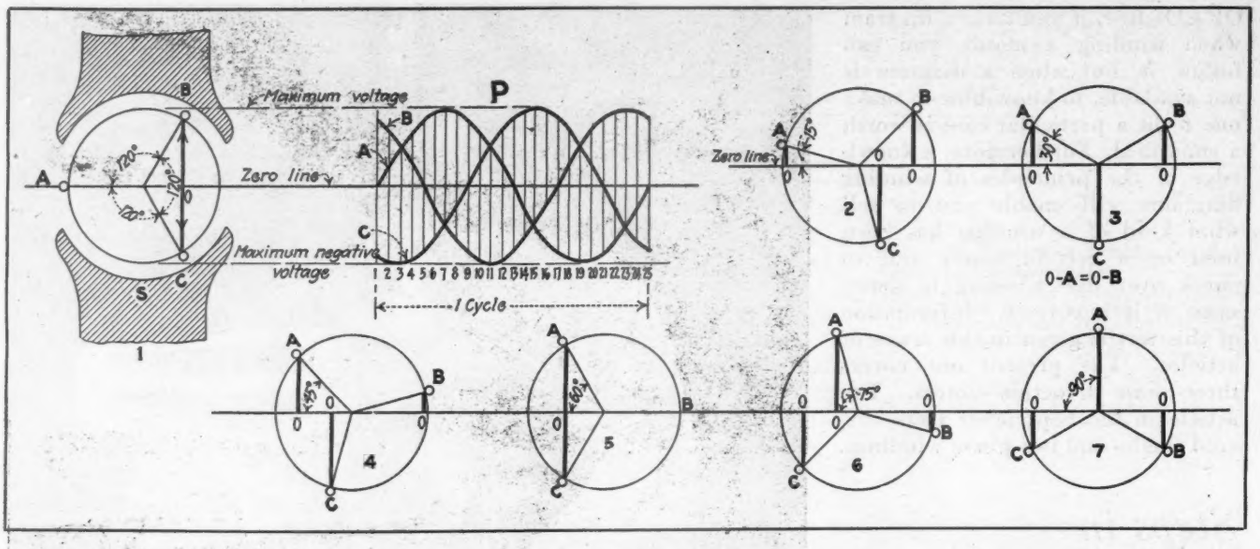


Fig. 1—Principle of a three-phase machine.

This is a simplified three-phase, two-pole generator with three conductors, *A*, *B* and *C*, located 120 degrees apart. As these revolve between the poles the voltages generated are equal respectively to the heavy lines, *A-O*, *B-O* and *C-O*, in the small drawings. The curves at *P* show the voltages generated during a cycle. Figs. 2 and 3 show the actual arrangement of coils in a motor.

to decrease. Voltage *A* continues to increase in a positive direction and *B* decreases until position 5, where it equals zero. Then *B* begins to increase in a negative direction as shown in position 6. The complete curves of all three of the phases are shown in *P* for one cycle.

A study of the voltages at any time will show that the sum of the three phases equals zero. For instance, at position 1, *A* phase equals zero, while *B* and *C* are equal but in the opposite directions; therefore, their sum is zero. In position 3, voltages *A* and *B* are positive while voltage *C* is negative. The sum of the three again equals zero.

The conductors shown in Fig. 1 are 120 mechanical degrees apart and at the same time 120 electrical degrees apart. In actual practice, however, this condition does not usually hold. Only in the case of consequent-pole windings are the adjacent groups 120 electrical degrees apart. In the case of practically all other windings the *A* phase and the *C* phase, for instance, are 120 electrical degrees apart, while the *B* phase is put in between these two, 60 degrees from each one. The correct electrical relation is accomplished by reversing the direction of the current through this *B* phase, which results in the final arrangement of 120 electrical degrees difference between each pair of phases. This is well illustrated in *D* and *E* of Fig. 8. This 60-degree arrangement is one of the pitfalls of three-phase windings and it should be thoroughly understood.

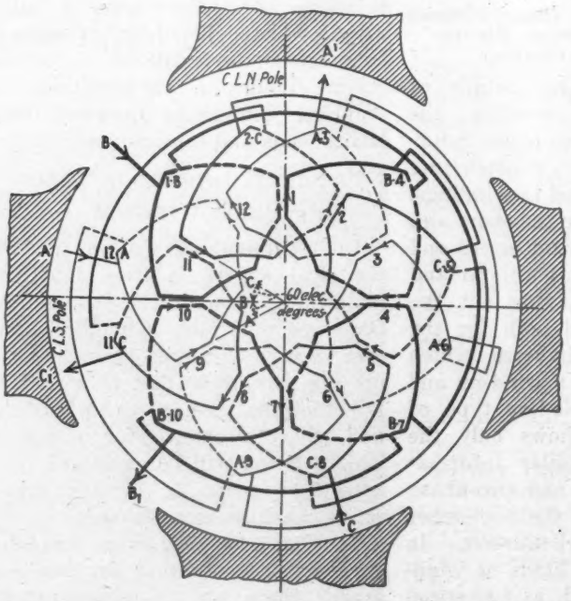
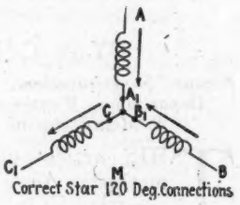


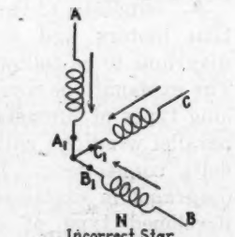
Fig. 2—Arrangement of coils in a three-phase motor.

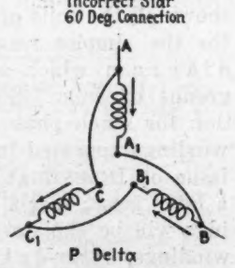
The large drawing shows how in an actual motor the groups of adjacent phases are only 60 electrical degrees apart instead of 120 deg. apart as shown in Fig. 1. This is explained in the article. The large diagram is for a four-pole, three-phase winding in which there are twelve slots and twelve coils. There is one coil per pole per phase, therefore one coil forms a group. The full pitch is $(12 \div 4)$, equals 3 slots spanned or 1-and-4. The jumpers are connected top-to-top. Single-line diagrams applying to the winding are shown in Figs. 4, 5, 7 and 8. At *M* is shown a schematic diagram of the motor winding connected correctly so as to give a 120-deg. relation of the phases although the groups are actually 60 electrical degrees apart. This condition is accomplished by reversing one of the phases, the *C* phase in this case. At *N* is shown the incorrect 60-deg. connection which results if one of the phases is not reversed, as at *M*. Diagram *M* shows a star connection. Diagram *P* shows how the delta connection is obtained.

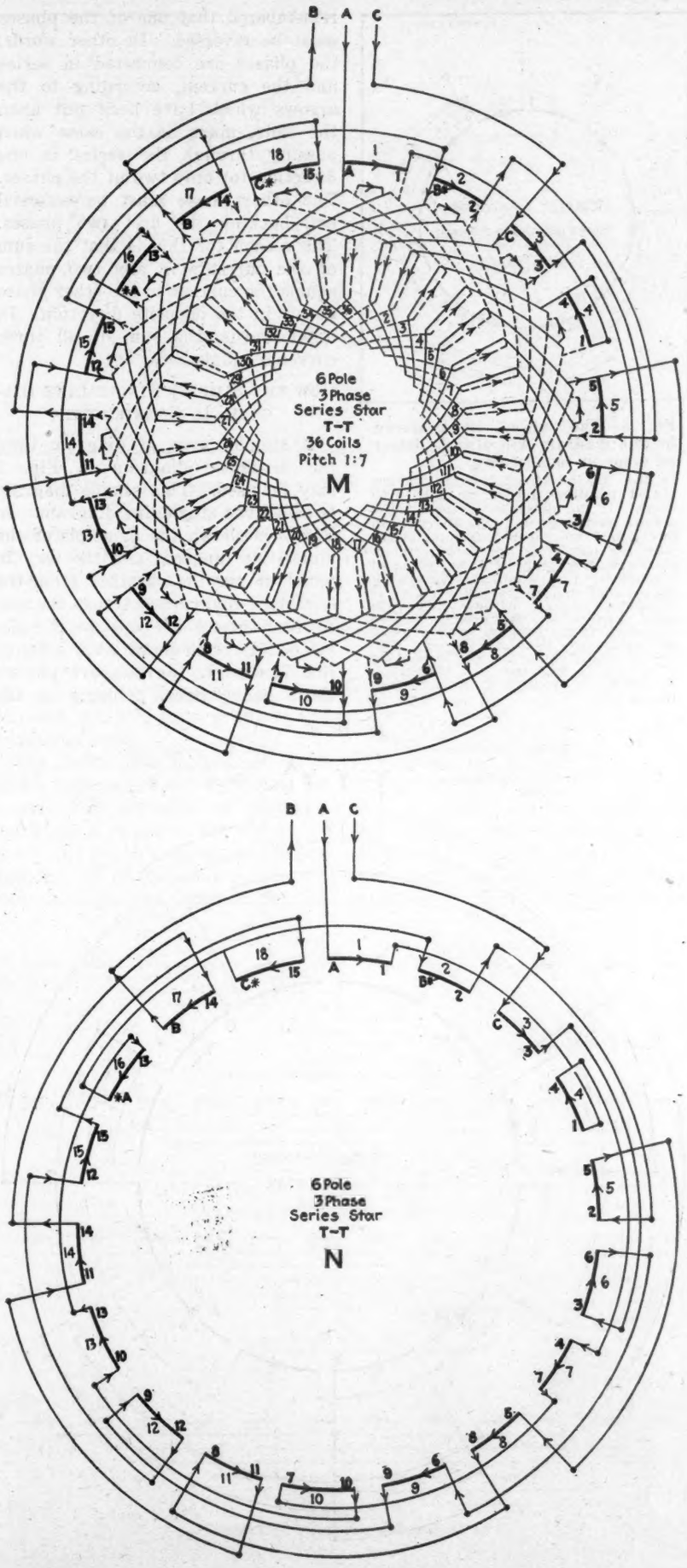
Constructing a Developed Diagram for a Three-Phase Machine

A three-phase winding is essentially three single-phase windings, all on the same core. After each single-phase winding is connected up, then the three windings are connected either in star or in delta, as the case may be. To draw a developed diagram of such a winding radial lines representing the coil sides in slots are first laid out as shown in Fig. 2. Then the coil pitch is determined. In Fig. 2 is shown a four-pole, three-phase winding with twelve slots. Since there are









twelve slots and four poles, the pitch will be equal to three slots or 1-and-4, which is full pitch. Sometimes a "chorded" pitch is used, in which case the number of slots spanned by a coil might be less than four and sometimes even greater. After the conductors in the slots are drawn, then the coils are drawn in as illustrated in Fig. 2. After the coil ends are drawn the arrows are put on the top conductors, all arrows under one pole space pointing in the same direction, while those under the next pole space point in the opposite direction. The arrows on the bottom sides of the coils are put in after the end connections of the coils have been drawn. Their direction is determined by tracing around the coils to see in which direction the current would flow.

The next thing to do is to connect the coils in groups. In this motor there should be 3×4 groups, as there are three phases and four poles. With twelve groups and twelve coils, this equals only one coil per group. Every third coil in the diagram will belong to the same phase. For instance, coils 1, 4, 7 and 10 belong to phase *B*. For the *B* phase then we may start at coil 1 and call the top lead an ingoing line lead. The next adjacent group of this phase is coil 4. The ingoing lead of this coil is a bottom lead; therefore, the bottom lead of coil 1 and the bottom lead of coil 4 are connected together. Likewise the top lead of coil 4 is connected to the top lead of coil 7, as the current is passing inward on this top lead. Then the bottom leads of coils 7 and 10 are connected together. The final lead of the *B* phase is the top lead of coil 10. This is called B_1. The other two phases are then connected up in the same manner, using any ingoing lead as the starting point and connecting every third coil together. After this is completed there will be six leads left, two for each phase. In order to use this motor on three-phase voltage, the winding must be connected in either star or delta.

As we have already seen from Fig. 1, there is as much current flowing

Fig. 3—How a simple single-line diagram is drawn from a developed diagram.

The heavy lines are put on the outside of each group as shown at *M*. Then the interior is removed, as shown at *N*, leaving the single-line diagram. This is a six-pole, three-phase winding connected with top-to-top jumpers in series-star. The same single-line diagram is used in Fig. 12.

into a three-phase winding as there is flowing out of it. Therefore for the line leads in Fig. 2 we must take one ingoing lead and one outgoing lead. For a series-star connection leads *A*, *B* and *C*¹ might be used for line leads and *A*¹, *B*¹ and *C* connected together to form the star. Or any other combination of leads might be used in which one outgoing and two ingoing leads are employed for line connections, or two outgoing and one ingoing lead are employed.

Beware of the 60-Degree Connection in Three-Phase Windings

There is a chance to make a wrong connection in three-phase machines, which is not present in one- or two-phase windings. This is the 60-degree connection which has already been mentioned. For instance, suppose that leads *A*, *B* and *C* were connected to the line while *A*¹, *B*¹ and *C*¹ were joined together to form the star connection. This would give a 60-degree connection as shown in *N* in Fig. 2, while the correct connection should be as shown at *M*. A machine connected as at *N* would not run as a motor nor deliver power as a generator. If the phases were equally balanced no current would flow, but if there were an unbalance present a circulating current would flow.

As a general rule, for a correct 120-degree star connection the line leads may be selected as follows: Take one group of any phase and call this group 1. Then count over to group 3 on each side of this group 1, and the two groups so found can be used for line leads. If a top lead were selected in the first group, top leads must be used also on the other two groups. Or if desired all the leads can be bottom leads. A 60-degree (incorrect) connection is shown in the single-line diagrams in Fig. 6.

A delta connection seems to some winders harder to understand than a star connection. However, as shown in *P* of Fig. 2, the delta connection is not hard if it is always remembered that one of the phases must be reversed. In other words, the phases are connected in series and the current, according to the arrows which have been put upon the slots, must be the same when passing through the series in one direction for only two of the phases. The other phase must be reversed and bucking the first two phases. The reason for this is that the sum of the currents in any two phases equals the current in the other phase but is in the opposite direction. In other words, the sum of all three currents equals zero.

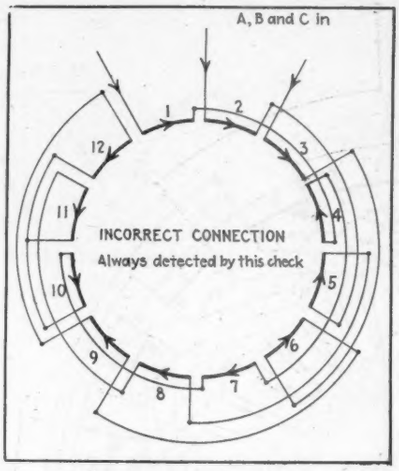


Fig. 5—The "all-in" check shown in this diagram will always detect an error in connections.

In the "all-in" check the arrows are placed pointing inward on all three leads. If the diagram is correct the arrows on the groups will alternate in direction. One group will point clockwise, the next group will point counter-clockwise, and this will be repeated throughout the winding. The check proves that the winding shown here is connected wrongly because there are three arrows on the groups in one direction. If the *B* phase were reversed the connection would be correct. The *B* lead should connect to the lower lead of group 11 and the star connection should go to group 2 on what is now the *B* lead.

How the Simpler Single-Line Diagram Is Constructed

A simpler type of diagram than the developed diagram in Fig. 2 may be used. This simple diagram is called the single-line diagram. In Fig. 3 is shown the principle of the single-line diagram and the way in which it may be obtained from the developed diagram. Across the end of each group of coils in the developed diagram shown at *M* a heavy line is drawn. Arrows are put on these heavy lines, pointing in the

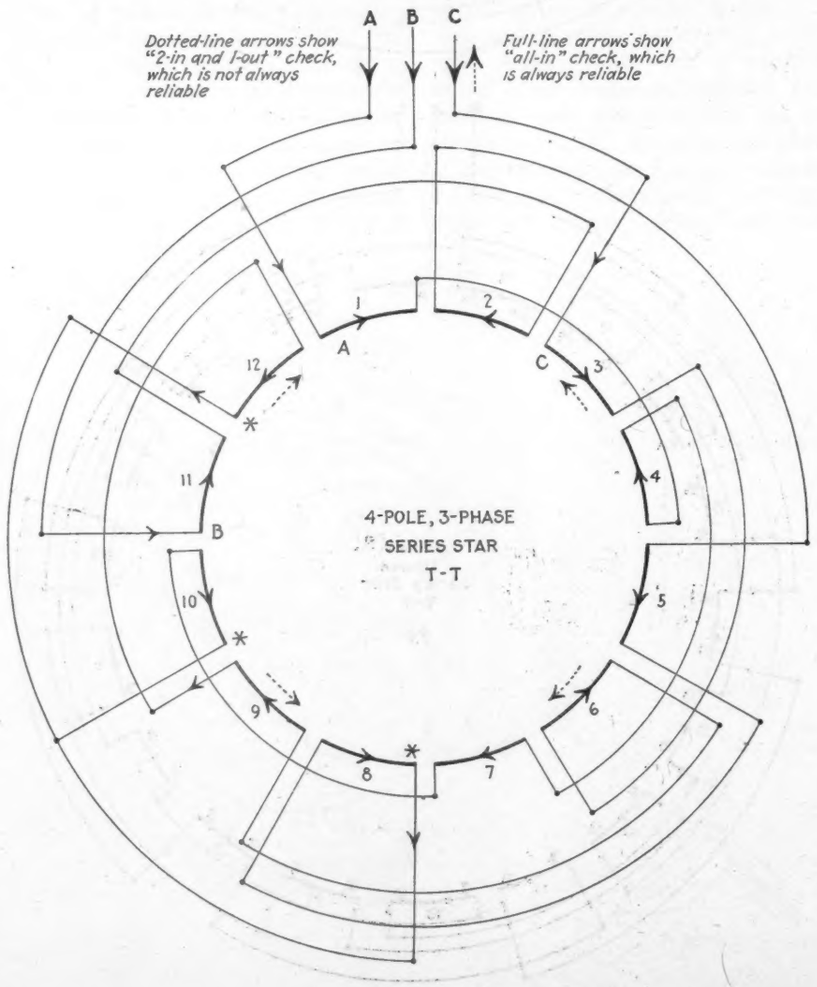


Fig. 4—How to check single-line diagrams by means of arrows.

The most reliable way to check a single-line diagram is shown by the full arrows. These arrows on alternate groups reverse direction. This is possible only when the arrows on the leads *A*, *B* and *C* all point *inward* (or all outward). The dotted arrows show the direction of current as taken from the developed diagram as Fig. 2 or Fig. 3. In this case the arrows on two leads (*A* and *B*) point inward while that on the *C* lead points outward. This latter arrangement of arrows will not always give a certain check as is demonstrated in Fig. 5.

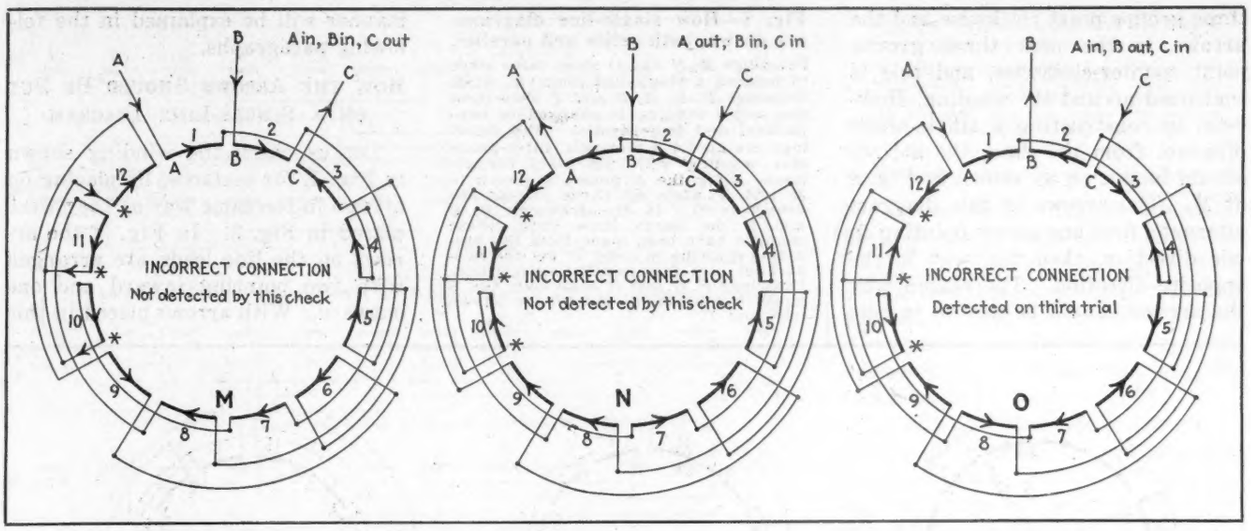


Fig. 6—This kind of arrow check is not always reliable.

This diagram shows the check where the arrows on two leads are pointed in, while that on the other is pointed out. Now when this check is used the rule is that three adjacent groups will have arrows in one direction while the next three groups will have arrows pointing in the opposite direction. This is repeated around the diagram. But as shown, three checks of this kind must be made. The diagram is drawn incorrectly, as the wrong end of the *B* phase is connected to the line, yet the checks at *M* and *N* fail to disclose the error. The third check, at *O*, shows that the connection is incorrect. Instead of this kind of check it is safer always to use the check shown in Fig. 5.

same direction as those on the stub connections from one coil to another in the group. Then the drawing inside of the heavy lines is cut out in order to leave the single-line diagram alone. Each of the heavy single lines then represents a group of coils. For the particular drawing shown at *M*, these lines represent two coils each. However, the same diagram will hold for a group of any number of coils.

The leads coming out of these single lines, as shown at *N*, are lettered. For instance, in group 1, the letter *A* is put at the end of the heavy line which connects to the line lead *A*. All of the leads which connect to lines are lettered in this way, *A*, *B* and *C*. Then opposite the star leads a star is placed, as in groups 16, 18 and 2. After this the other leads are numbered. Starting at group No. 1, the first lead which does not have a number is given the number 1 and a figure 1 is written underneath this lead as shown. This lead connects by means of a jumper to a lead in group 4, and a figure 1 is also put at the end of group 4, as shown. Then going back to group No. 2, the next lead which is not numbered is the bottom lead. This is given the number 2. In the same way as before, this connects with a lead in group No. 5, and this bottom lead in group No. 5 is also called No 2. The leads are taken up in this way in succession around the diagram until every lead has a number. Then, it is known that the leads which have the same number are connected together by jumpers.

How to Construct a Single-Line Diagram

In constructing a single-line diagram, the first step is to draw the heavy single lines in a circle, as shown at *N* in Fig. 3. There is one heavy line for each group in the winding. The next step is to put on the arrows showing the direction of current in the group, but this should not be done as it is done in Fig. 3. In this figure, the arrows in the first

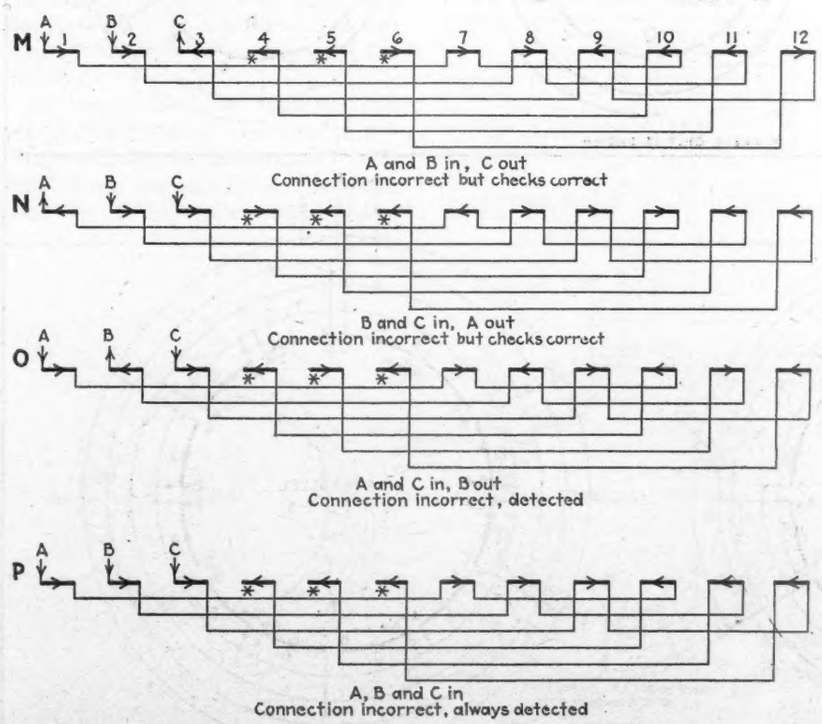
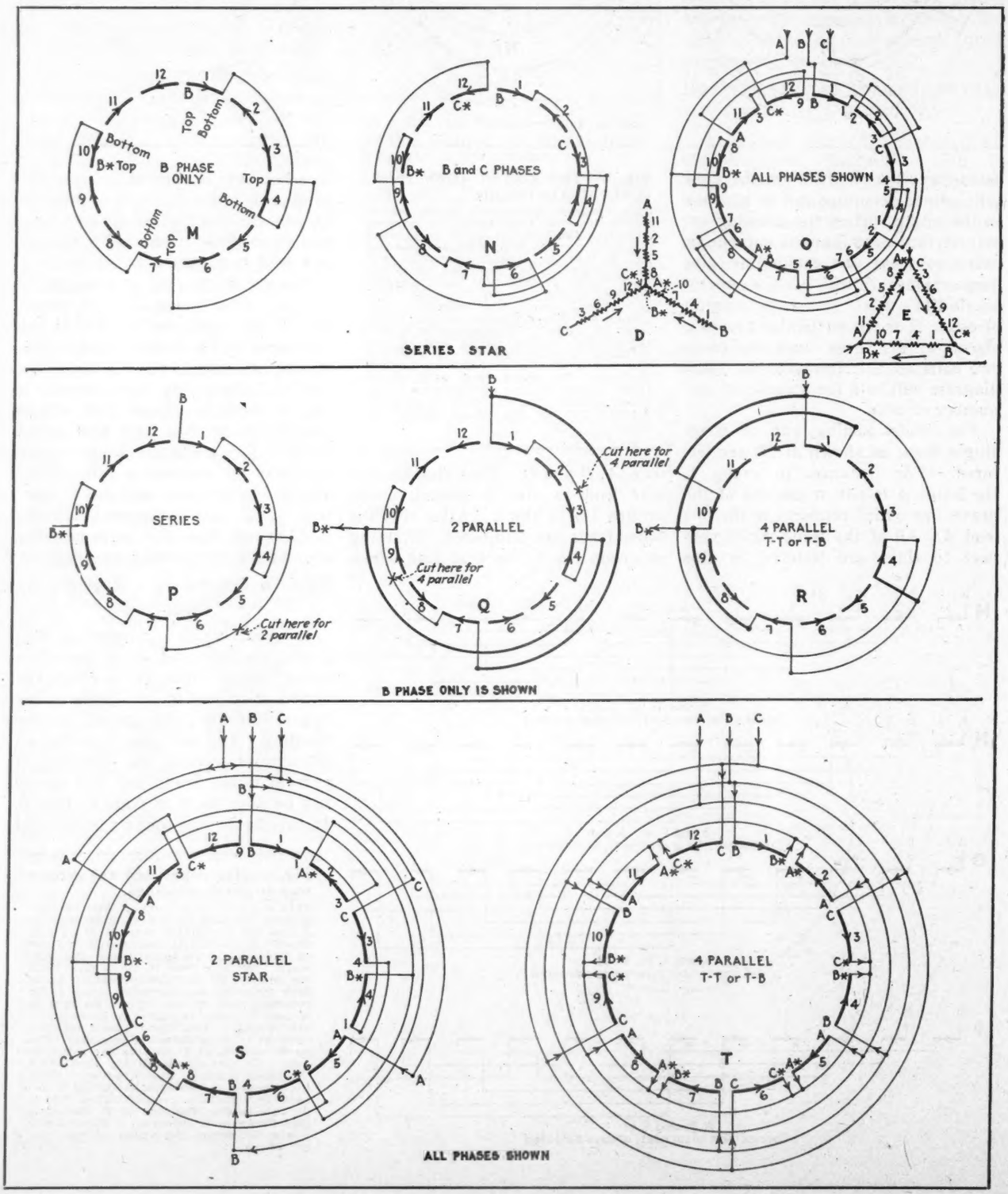


Fig. 7—The right and the wrong way to check windings.

This shows a long-jumper type of connection checked in the reliable way at *P* and the unreliable way at *M*, *N* and *O*. At *M*, *N* and *O* the arrows are put on the leads, two inward and one outward. With arrows in these directions the arrows on the groups shown point first three in one direction, then three reversed, and so on. They do this in *M* and *N* even though the connections are wrong. The third check of this kind, at *O*, does show the mistake. The check shown at *P* detects the error at once. In this check all the arrows on the leads point in one direction. Then the arrows on the groups should alternate on alternate groups. They fail to do this in the diagram at *P*, therefore this diagram is incorrect. Figs. 5 and 6 also illustrate the value of the "all-in" check.

three groups point clockwise and the arrows in the next three groups point counter-clockwise, and this is continued around the winding. However, in constructing a single-phase diagram from the data, the arrows should be put on as shown in Fig. 8 at *M*. The arrows in this diagram alternate, first one arrow pointing in one direction, then the next in the opposite direction. The reason why the arrows should be put on in this manner will be explained in the following paragraphs.

Fig. 8—How single-line diagrams are drawn, both series and parallel. Drawings *M*, *N* and *O* show three steps in making a single-line diagram, while drawings *P*, *Q*, *R*, *S* and *T* show how the series winding is changed to two-parallel and four-parallel. The drawings are all for a four-pole, three-phase star winding with top-to-top connections. Only the *B* phase is shown in *M* and *N* while all three phases are drawn in *O*. In the drawings *P*, *Q* and *R* the heavy lines show where changes have been made from the preceding drawing in order to get the two-parallel or four-parallel connection. Drawings *P*, *Q* and *R* show only the *B* phase but all three phases are shown in *S* and *T*.



How the Arrows Should Be Put on a Single-Line Diagram

Let us check the winding shown in Fig. 4, for instance, by placing on arrows in the same way as they were placed in Fig. 3. In Fig. 3, the arrows on the line leads are arranged with two pointing inward and one outward. With arrows placed in this

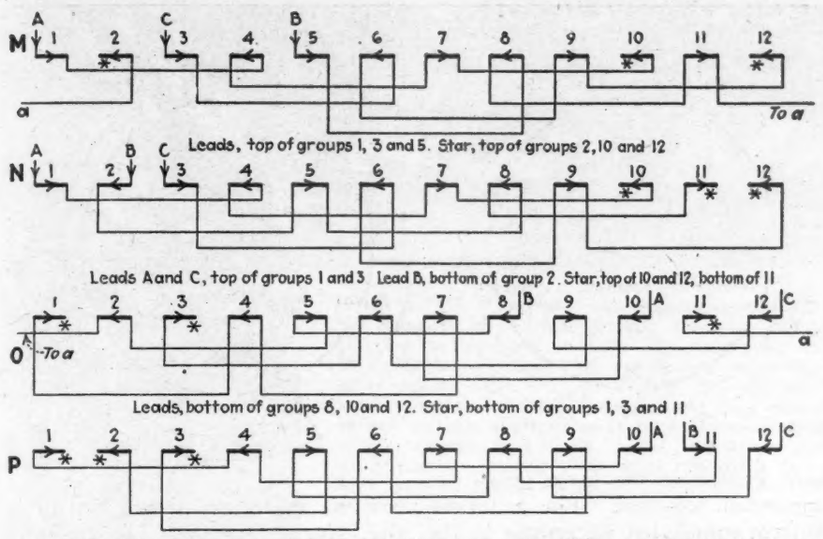

Leads, top of groups 1, 3 and 5. Star, top of groups 2, 10 and 12
Leads A and C, top of groups 1 and 3 Lead B, bottom of group 2. Star, top of 10 and 12, bottom of 11
Leads, bottom of groups 8, 10 and 12. Star, bottom of groups 1, 3 and 11
Lead B, at top of group 11 Leads A and C, bottom of groups 10 and 12. Star, top of 2 and bottom of 1 and 3

Fig. 9—Various positions in which line leads may be placed.

These diagrams are all for a four-pole, three-phase, series winding with top-to-top connection (short jumpers). As will be seen, the line leads are put on in four different ways, but each is correct.

way on a correct diagram, the arrows on the groups will alternate, first three groups pointing in one direction, and the next three groups in the opposite direction. This check, however, is not always reliable, as will be explained later, because sometimes the arrows in the groups may point in the correct direction and yet the winding may be incorrect. In Fig. 4 the arrows drawn in full lines show the correct method of checking the groups, while those drawn in dotted lines show the unreliable method, or that used in Fig. 3. For the correct check as shown in Fig. 4, the arrows point inward on all of the line leads. The arrows on the groups alternate first in one direction and then in the other entirely around the winding.

To prove that the "two in and one out" method of checking is not always reliable, let us examine Fig. 6. This shows the unreliable check applied to a four-pole, three-phase, series-star diagram. This gives three cases of using this check. In each case, two of the arrows on the line leads point inward, while one points outward. In *M* and *N* the arrows on the groups point in one direction on three groups and then in the opposite direction on the next three groups, and this is repeated around the diagram. According to the rule for this check, this would indicate that in both of these cases the diagram is correctly drawn. However, by a third application of the same check in *O* of Fig. 6, it is found that the arrows on the diagram alternate, first in one direction and then in the other. For this kind of a check, this shows that the connections are not correct. In the two cases of *M* and *N*, where the same check was applied, however, the mistake was not detected.

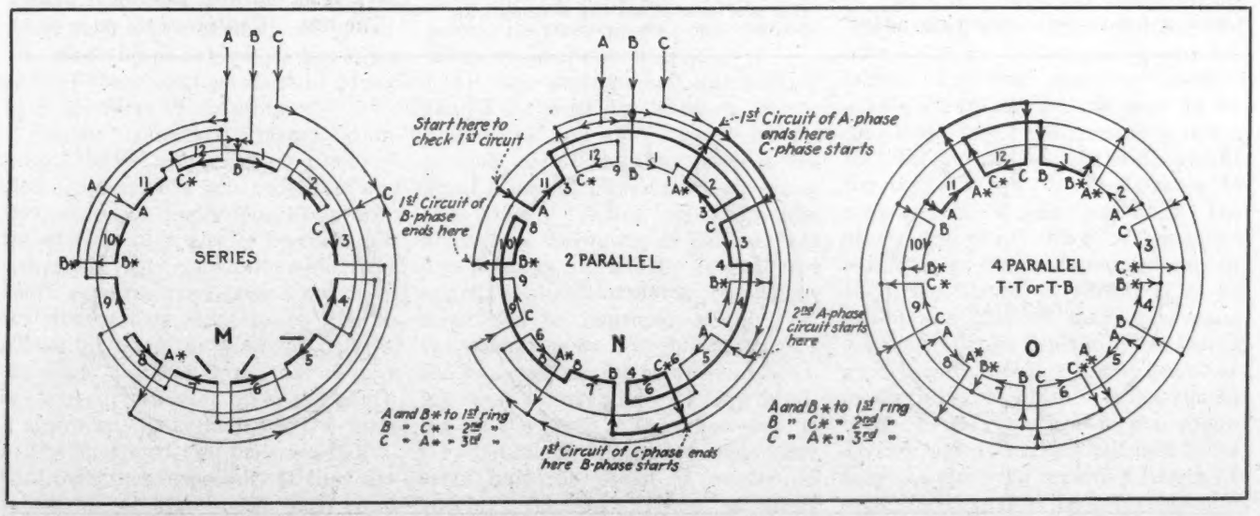
In applying the check shown in Fig. 5, all of the line leads have the arrows pointing inward. Then, the current is traced through all of the groups and arrows put on them according to the direction of the current. Finally, if the arrows alternate, first in one direction and then in the other entirely around the windings, the connections are correct.

It is seen in Fig. 5, however, that the arrows do not alternate in this way, and, therefore, the diagram in Fig. 5, which is the same as that in Fig. 6, is not correct.

In Fig. 7 again is shown the reliability of the "all in" method of checking and the unreliability of the "two in and one out" method. The checks are applied in Fig. 7 to the long type of jumper, while the diagrams shown in Figs. 5 and 6 have the short type of jumper. All four of the diagrams shown in Fig. 7 are the same, and the connections are incorrect. By applying the checks in *M* and *N*, however, no error is detected. The "two in and one out" method does detect an error in *O*, but this might be the third trial, as it does not detect it in *M* and *N*. However, the "all in" check shown

Fig. 10—Delta-connected windings, series and two-parallel.

These drawings show a four-pole, three-phase winding connected top-to-top. The heavy oblique lines inside the circle at *M* show how chalk marks may be put in an actual stator to indicate the direction of flow of current. The heavy lines in *N* show how to check a two-parallel, delta winding. One of the two parallel circuits has been checked by following the black lines. At *O* is the four-parallel diagram. The heavy lines show the path in checking one of the four parallel circuits.


SERIES
2 PARALLEL
4 PARALLEL
T-T or T-B
Start here to check 1st circuit
1st Circuit of A-phase ends here C-phase starts
1st Circuit of B-phase ends here
2nd A-phase circuit starts here
A and B* to 1st ring
B " C* " 2nd "
C " A* " 3rd "
1st Circuit of C-phase ends here B-phase starts

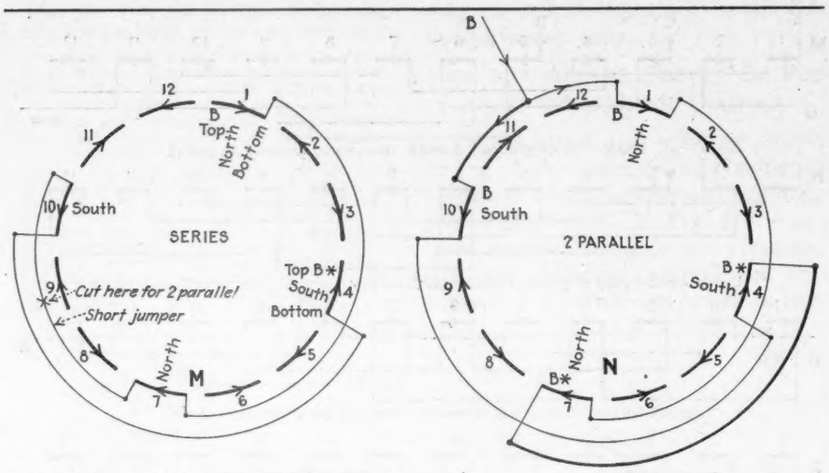


Fig. 11—Top-to-bottom type of connection, series and two-parallel. This shows a four-pole, three-phase, star winding with the top-to-bottom, or long, jumper. At *M* is a series connection, while at *N* is a two-parallel connection. The heavy lines in *N* show where changes have been necessary to convert the series to the two-parallel connection.

in *P* never fails to detect the error. As seen in *P*, the arrows point, first, three in one direction and then three in the opposite direction, and this shows that the connection must be wrong. For this "all in" check, the arrows in the groups must alternate, the first arrow in one direction and the second arrow in the other direction, and so on.

Therefore, in checking the single-line diagram, the arrows should be put on as shown in *M* of Fig. 8, the arrows on the line leads all pointing inward and those on the groups alternating first one arrow in one direction, then another in the opposite direction. This check is based on the fact that if direct current flows inward from each line of a properly connected series motor, and a compass is held against each group, the polarity of each successive group will reverse.

Therefore, in constructing the single-line diagram, first the arrows are put on the groups, making one arrow point first in one direction and the next arrow in the opposite direction, and repeating this around the winding as in Fig. 8. Then, put the group numbers on the curved lines. In any three-phase winding, every third group (1 and 4) belongs to the same phase. The alternate groups of the same phase are in poles of opposite polarity. In other words, if group No. 1 is in a north pole, then group No. 4 will be in a south pole. Similarly, group No. 7 will be in a north pole.

For a top-to-top connection adjacent groups of the same phase are connected together. For a top-to-bottom connection all groups in the north poles are first connected in series and then a short jumper is used to connect this series with the series of all south poles. The difference between the top-to-top (short) jumper and the top-to-bottom (long) jumper is explained fully on page 467 of INDUSTRIAL ENGINEER for September.

The diagram in Fig. 8 is for a top-to-top connection; consequently the first group is connected to the fourth. Calling the top lead of group No. 1 the *B* line, then connect groups No. 1 and No. 4 together, so that the arrows are followed. In other words, the bottom of group No. 1 connects to the bottom of group No. 4. Groups No. 4 and No. 7 are next connected together. The top of group No. 4 is connected to the top of group No. 7. Then, the bottom of group No. 7 is connected to the bottom of group No. 10, and as all the groups in the *B* phase have been covered, the top of group No. 10 is the star connection. In passing through this series of groups from one end to the other, it will be noted that the passage is first clockwise (in group 1), then counter-clockwise (in group 4), then clockwise (in group 7) and then counter-clockwise (in group 10). In other words, the direction alternates from one group to the next. This holds always with the top-to-top connection, but with the top-to-bottom connection the first series of groups is passed in one direction and the second series in the opposite direction.

In Fig. 8 after the *B* phase is connected as in *M*, the *C* phase is drawn in, as shown in *N*. To locate the start of the *C* phase, count over from group 1 to 3. Then the *C* line will connect to the top lead of group 3. The bottom of group 3 will connect to the bottom of group 6. Then the top of group 6 connects to the top of group 9, the bottom of 9 connects to the bottom of 12, and the top of group 12 forms the second star connection. After this phase is drawn, check it as outlined for the *B* phase.

The line *(Continued on page 516)*

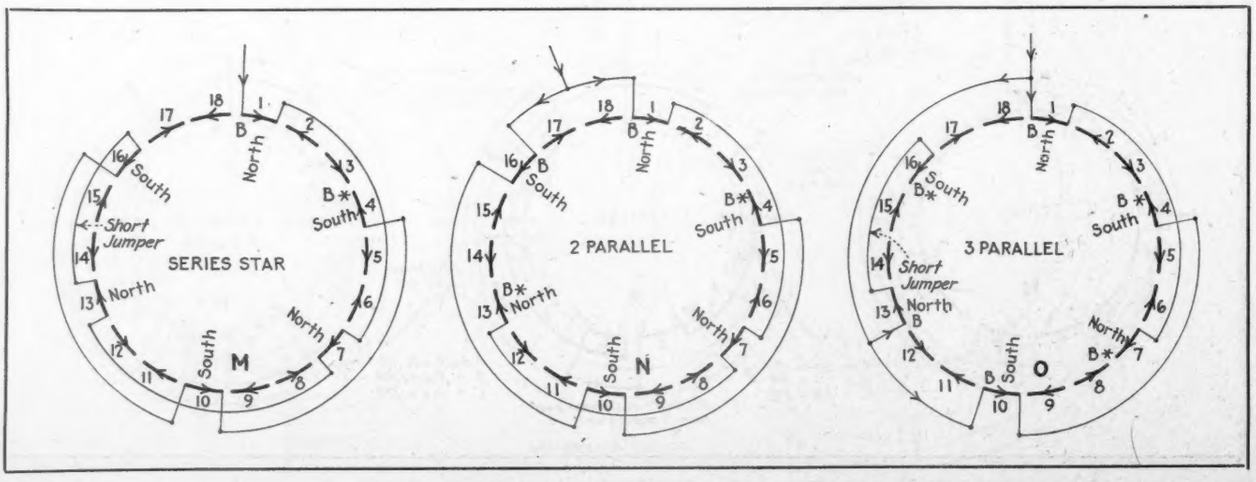
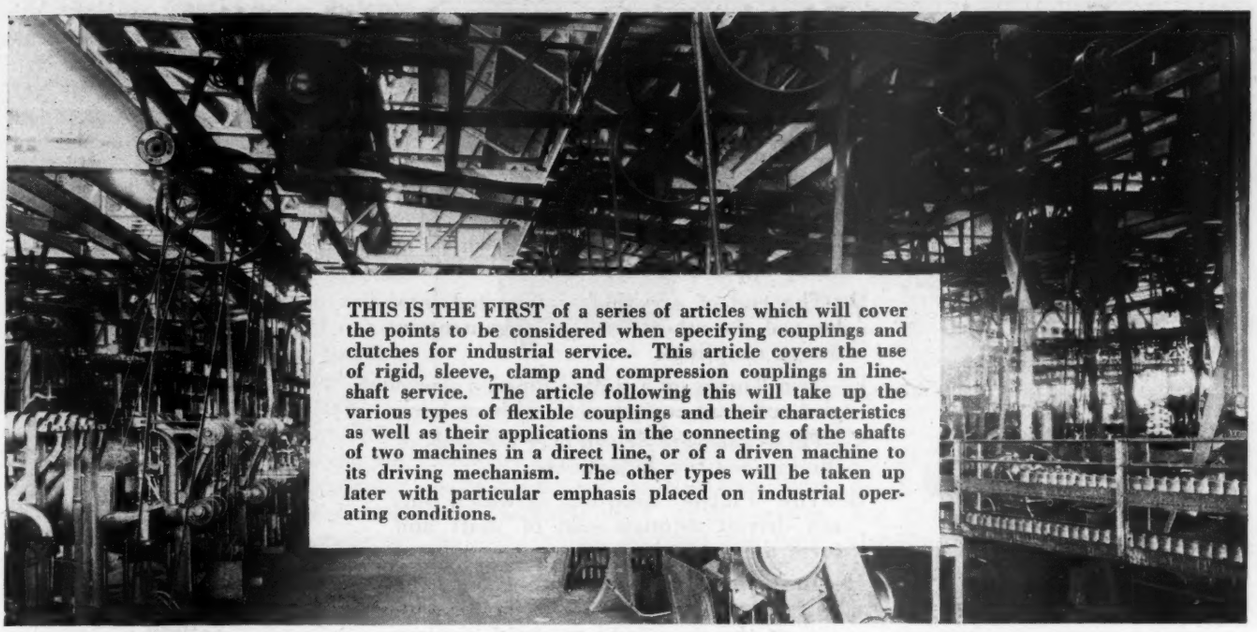


Fig. 12—Six pole winding connected series and parallel. This is a three-phase star winding with top-to-bottom (long) jumpers.



THIS IS THE FIRST of a series of articles which will cover the points to be considered when specifying couplings and clutches for industrial service. This article covers the use of rigid, sleeve, clamp and compression couplings in lineshaft service. The article following this will take up the various types of flexible couplings and their characteristics as well as their applications in the connecting of the shafts of two machines in a direct line, or of a driven machine to its driving mechanism. The other types will be taken up later with particular emphasis placed on industrial operating conditions.

Some Factors Which Affect the

Use of Rigid and Compression Couplings

When Employed in Connecting Lineshafting in the Mechanical Transmission of Power in Industrial Works

By FRANK E. GOODING
Associate Editor, Industrial Engineer

WHERE several machines are operated together, as in many shop drives, lineshafting is used to convey power from the motor, engine or other source of power to the point where these individual machines are located. Because such a line of shafting is usually made up of several sections, the ends of these sections must be joined by some form of coupling.

Flange couplings, clamp couplings, sleeve couplings or compression couplings are generally used and the choice is made depending upon the amount of power to be transmitted, upon the speed at which the shaft revolves, and upon how often the shafts may need to be disconnected, or upon the kinds of pulleys, bearings, clutches, etc., that it may be desired to mount upon the shaft.

However, in connecting the ends of the shafts of two or more individual machines, especially if they are to operate at high speed, such rigid couplings are usually not satisfactory and flexible couplings are preferred. The numerous types of these flexible couplings, their characteristics and application will be taken up in the next article.

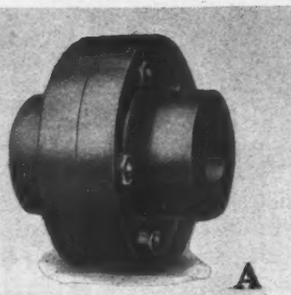
All the sections of lineshafting should be carefully lined up in the first place and they should be realigned occasionally to prevent too great a loss of power through excessive bearing friction caused by misalignment. However, as the bearings and hangers are usually several feet apart, a slight error in the alignment due to improper aligning at the start, due to a slight shifting of the hangers, or due to unequal bearing wear is taken care of by a bending of the shaft. This, however, is very wasteful of power; in some cases half the power is wasted in bearing friction. When a shaft shrieks or squeals when starting or stopping, usually it is a sign that it is badly out of line. Flexible couplings might be used to overcome part of this waste but they are more expensive to install and they are not necessary because the shaft should be and usually can be kept in reasonable alignment at less expense.

Some Types of Rigid Flange or Plate Couplings

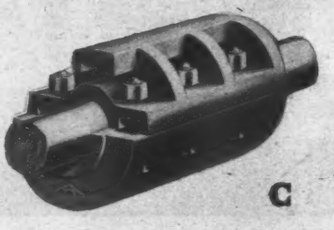
The most common type of rigid couplings is the flange or plate coupling shown at *A*. These are made for all sizes of shafts and are for the primary purpose of rigidly connecting two lengths of shaft sections to make one continuous section. On more or less semi-finished work such as low-speed transmission shafting, these flange couplings may be forced on the ends of the shafts and keyed in position. For this semi-finished work often only the bore, face and outer rim of the couplings are finished. The bolts may have considerable clearance in the bolt holes. The usual test of alignment is to see that the outer rims of the flanges fit together. When it is desirable to center the flanges one with the other, one shaft may be extended through its flange into the bore of the other flange, as shown at *D*, or one flange may be made male and the other flange female by cutting a groove in one flange and a shoulder in the other to fit into it, as shown at *B*. Usually the groove and shoulder are placed outside the bolt holes near the rim. To remove a length of such shafting it is necessary to slip

Examples of Rigid and Compression Couplings

Construction of Various Types for Lineshaft Use



A



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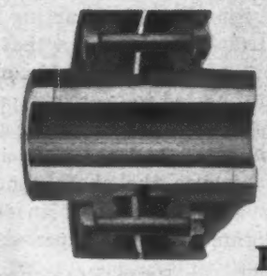

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A—The flange or plate couplings are the most common for lineshaft work.

B—The groove and shoulder of the male and female flange coupling.

C—One type of clamp coupling which is easily applied or removed.

D—The end of one shaft is inserted into bore of the other to affect alignment in flange couplings.

E—Two flanges on a slotted tapered sleeve give sufficient compression without keys.

F—These rings are driven over the ends of the tapered two half-sleeves.

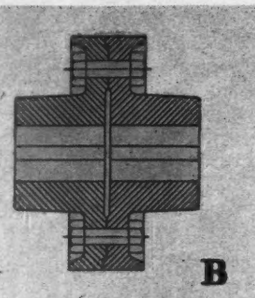
G—The "Pintite" coupling, in which pins are driven through side of shaft and form their own keyway.

H—In this compression coupling two cone rings are bored tapering to fit the outside of the sleeve and are held in place by a threaded-in-collar.

I—A cross-section of the cone-ring compression coupling *H*.

J—A double-cone compression coupling, pulled together by bolts, makes a very strong coupling which is easily attached or detached.

K—A cross-section which shows the assembly of coupling *J*.



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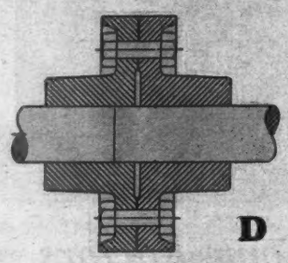

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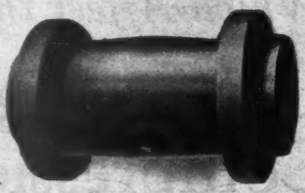

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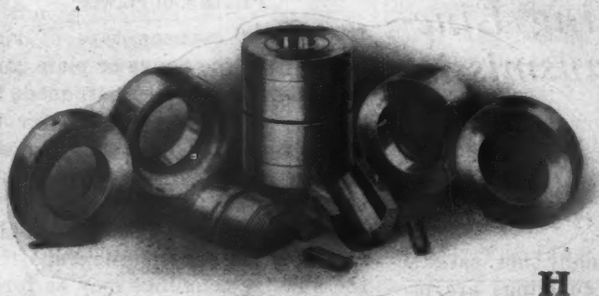

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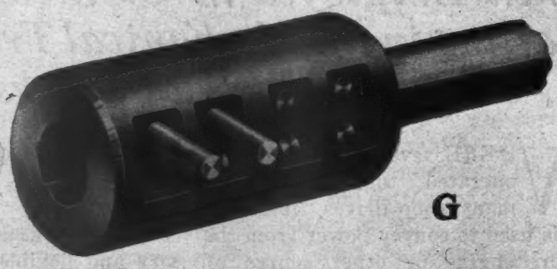

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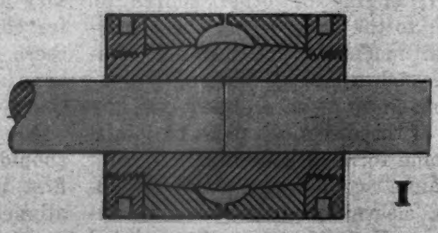

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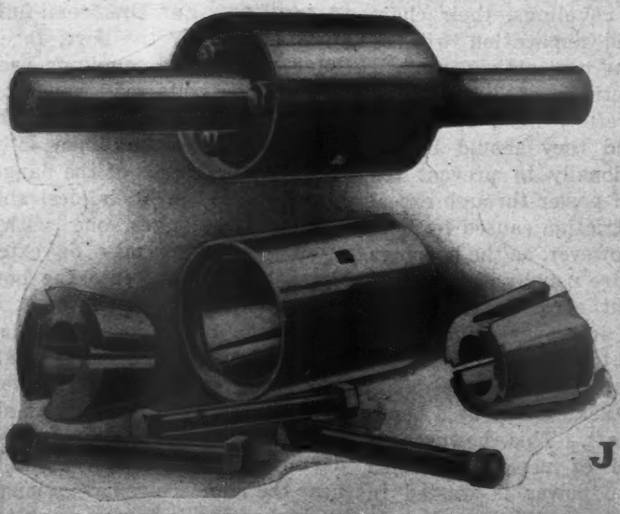


J

K

the shafting lengthwise, a distance equal to the shoulder.

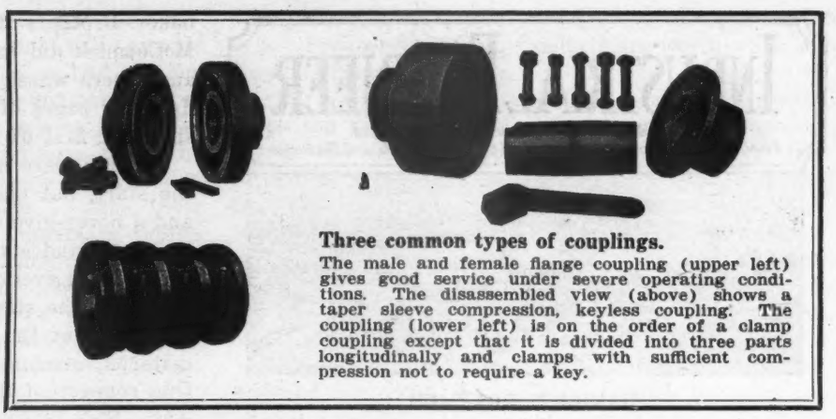
For high-speed transmission shafting the usual practice is to mount the flanges on the ends of the shafts and then key in position, after which the shaft is put in the lathe and the flanges are trued up with the shaft. Frequently the bolt holes are also reamed through and body-bound bolts are used to get the full effect of the strength of the bolts as well as the friction drive between the faces of the flanges. This type of coupling is used almost exclusively for coupling 6-in. or larger lineshafting.

Occasionally, seasonal or other periodical fluctuations of production make it advisable to have infrequent disconnection of the shafts so that parts of a line only need be operated. For such places regular flange couplings can be fitted with separating plates between the coupling halves. These plates are usually cast iron half rings machined over-all and with reamed holes for the coupling bolts. When the shafts are to be disconnected the coupling bolts are removed, the separating plate taken out and the coupling halves are no longer connected.

Standard flange couplings are usually conveniently stocked in most mill supply houses. An extra charge is usual for male and female couplings as well as for reducing couplings which are used for connecting shafts of different diameters. Flange couplings are often pressed on the shafts and therefore are difficult to remove if occasion demands. They also prevent the use of solid pulleys, ball and some types of roller bearings and clutches unless put on before the shafting is erected.

Clamp couplings are commonly used on lineshafts up to about 4 in. in diameter, although, some special types are used on larger shafts. One of the big advantages of this type lies in that the couplings are easily installed or removed after the shaft is in place, and nothing interferes with installing solid pulleys, collars, clutches, or ball bearings and roller bearings which must be slipped on over the end of the shaft. Clamp couplings are divided longitudinally into two halves which are drawn together by bolts and are usually fitted with a key. They are ribbed for strength and to shield the bolt ends from catching clothing. For real safety it is best to cover them, particularly where they may come in contact with clothing. Most manufacturers provide at an additional charge a special steel shell or cover which entirely encloses the surface and also prevents the coupling from picking up dust or lint. Clamp couplings are usually used on fairly slow speed work. The principal advantage is the ease with which they may be installed or removed. Frequently clamp or compression couplings are used in emergency repair of broken lineshafting.

For small lineshafting up to perhaps 1⅛ in. diameter and operating under comparatively light loads, solid sleeve couplings are sometimes used. These are merely a hole through a solid bar and are slipped over the ends of the shaft. The driving is done through set screws although sometimes both keys and set screws are used. A special type of sleeve coupling is illustrated at *G*. Cup-ended hardened pins are driven into the shaft as shown and cut their own cross keyways. These pins may be driven out backwards where it is desired to remove the coupling. These are made for all sizes of shafts up to 5⅛ in. diameter and in reduction sizes. These couplings may be used when the power to be transmitted is well up to the capacity of the shaft and where low first cost is a consideration.



Three common types of couplings.

The male and female flange coupling (upper left) gives good service under severe operating conditions. The disassembled view (above) shows a taper sleeve compression, keyless coupling. The coupling (lower left) is on the order of a clamp coupling except that it is divided into three parts longitudinally and clamps with sufficient compression not to require a key.

Press for forcing flange couplings upon lineshafts.

Types of Compression Couplings and Their Application

Compression couplings like clamp couplings, are used primarily on lineshaft drives of moderate or light-duty capacity where one consideration is the possibility of quickly tearing down a section either to move or to insert or to remove pulleys, ball or roller bearings, clutches and similar attachments. Practically all types of compression couplings depend upon some means of gripping the two ends of the shaft by various methods which impart enough friction to keep the ends from slipping. Several of these types do not rely upon keyways in the shaft. In general these couplings fall into four classes: (1) A double taper sleeve within two flanges which are taper bored to receive the ends of the sleeve. (2) Couplings which comprise two inverted cones within a solid taper sleeve. (3) Taper bearing pieces within two flanges which have tapered keyways to receive these pieces. (4) A tapered spiral sleeve within two flanges which are taper bored to fit sleeve. (*Continued on page 517.*)

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, October, 1923

Goodbye Steam Engine in Rolling Mills!

IT HAS been said that some men change their minds quickly when conditions justify it; others require two, three, four or five years, and others never change their minds. To get new developments into plants operated by the last-named class means that old age or pension time must be abided. The number of this group in the steel industry, however, seems to be very few, for we find the following paragraph in the recent report on developments in steel mill work presented at the Buffalo convention of the Association of Iron and Steel Electrical Engineers.

Operators are realizing more and more that they cannot afford to keep these old steam engines in operation. They are inefficient in their use of steam and require constant attendance and maintenance. It is not an uncommon thing from saving of attendance, maintenance and repairs to more than pay for the fixed charges on the electrical installation, leaving a saving in power consumed as sure profit. The steam-driven mill is slowly but surely being supplanted.

Things must move with certainty in a steel mill and the steam engine has served long and faithfully as a source of power on this basis. But today the success of most operations is measured in operating costs and profits and electric motors on main drives have to their credit sufficient evidence of reliability and savings in operating costs to convince even the pessimists in the older mills and as the report says: "The steam-driven mill is slowly but surely being supplanted."

Can a Turtle Climb a Tree?

MOST of us have a something in our thinking equipment that, when a hard or new job comes along, prompts the overworked expression: "It can't be done" or "It isn't worth while." Yet around every one of us are the results of the work of someone who undertook these "can't-be-done" and "not-worth-while" jobs and has built institutions around them. Men who started as Henry Ford did as a mechanic, as Matthias W. Baldwin did as a machinist, as the Studebaker Brothers did as wagon builders, as Cyrus H. McCormick did in building a mechanical grain cradle, and others whose great works have been shown in the first few pages of each issue of INDUSTRIAL ENGINEER since the first of this year.

These were men of apparently ordinary ability at the start, but endowed with a forward-looking vision and a never-give-up spirit. They tackled a problem of their age and stayed with it. A problem of this day and time in every industrial works is production control from the standpoint of the quality, quantity, cost and profit of the product produced, starting with raw material, machine equipment and operating labor. In this connection the elimination of shutdowns and the waste they represent is a worth-while job for any man whose work calls for an analysis of operating troubles and ways of preventing them.

Right here a little story carries a point that is just as serious as it may appear funny. A father in entertaining his little son with bed-time stories read one about a hungry alligator creeping up behind a turtle, with its jaws wide open and dripping. Just as it was about to swallow the turtle, the turtle gave a spring, ran up a tree and—lived. "But," said the little son, "how could the turtle climb a tree?" "By golly," replied the father, "he just had to," and that settled it.

So if you are up against a tree just climb it and when you get up there thank the alligator.

Experience Is a Good Teacher, But—

WHEN everything is running smoothly in a manufacturing plant and production schedules are easily carried out the inference is that the processes are well laid out and every man is doing his part on the program from the raw product end to the shipping platform. In such cases conditions may be as good as they seem to be until a need for speeding up the output or putting through a rush order is essential and then in order to find the trouble somebody must be taken off his production job to make a detailed investigation. The bigger the plant the more difficult the problem and the longer it takes to change the routine or equipment to fit the new conditions.

In one works employing about 6,500 persons where a survey of department operations was made by the use of graphic records, some startling wastes that had been going on for a long time were discovered. After installing graphic instruments to get a record of the power consumed, the following report was made:

An examination of the records showed that although the machines were started at six-forty o'clock the workmen were very slow in getting started, and it was seven forty-five before this department was running at full load. At ten-thirty work began to slow up, and the power used by the machines decreased so that at twelve o'clock the department was running at only half load. In the afternoon it took the same length of time to get started, and at three-forty the employees began to anticipate quitting time, the work falling off so rapidly that before five o'clock the department was practically idle. The wasted time of the workmen represented a loss of 11.8 per cent of the working time. At the time this record was made there were 460 operatives in this department using power-driven machines. The average rate of pay was $4.68 per nine-hour day. The loss in labor effort shown by this record was 460 × $4.68 × 11.8 per cent=$250 per day, which represents an annual loss of $75,000 per year of 300 days in this department alone.

The graphic meter is not the cure-all for such conditions but it is an instrument that will provide continuous evidence of conditions, good or bad, as they exist from day to day and furnish comparisons of results that will help to determine where corrective measures or studies of operating conditions should be directed to keep operations and processes up to known standards of efficiency, help workmen to earn their bonuses and enable the plant to earn a maximum return through a continuous and uniform loading of machines, and proper distribution of power and labor costs for each operation while a product is being made. They make it unnecessary to wait during a long period of operation to secure data to justify the original production estimates and guesses.

The graphic instrument has changed the old saying that "experience is a good teacher if it don't cost too much," to this form: "Experience is a good teacher, but it should be graphically recorded."

Electric Heat in Iron and Steel Mills

IN THE report of the electrical development committee presented at the Buffalo (N. Y.) convention of the Association of Iron and Steel Electrical Engineers last month and abstracted in this issue, special reference was made to new uses of electric heat in steel mill operations. One use is particularly interesting because it seems to provide a remedy for roll breakage, a mechanical trouble, and shows how closely electrical and mechanical operations of equipment are related.

Another reference is made to the use of electric steam boilers such as described in the August issue of INDUSTRIAL ENGINEER, page 403. While the electric boiler was first used in Europe on a large scale the applications made in this country during the past year are more novel and on a wider scale than anywhere else in the world today. Where surplus power from fluctuating loads is available these units have proven a very effective means of keeping the load factor constant both in cases where power is purchased and where it is generated. In one plant electric boilers are operated only Sundays and holidays, or about 60 days a year, and have justified their cost on this basis.

Byproducts of Better Methods for Handling Materials

THE OBVIOUS difficulty of prophesying accurately in advance the results from better methods of handling material is one of the biggest difficulties in the way of persuading industrial men to change methods and add equipment, particularly if this involves a considerable expenditure or important revisions of the manufacturing operations. However, if the equipment is properly designed, the results are usually more satisfactory than had been anticipated.

Every improvement in the methods of handling materials in industrial plants should be primarily designed to attain one or more of the following results: a saving in the time of doing the task or in wages of the men involved, lower unit costs as a part of a new production plan, greater reliability or continuity of service. While these are the main results, other advantages, some of which may be totally unexpected, are often found to accrue. Frequently these byproducts are worth-while savings in themselves.

As an example, in one plant it was necessary to truck the trolleys and hooks used on a long monorail carrier back to the starting point. A continuous overhead link conveyor was installed as it was estimated that the saving in truckers' wages would soon repay the installation cost, which it did. Even after an allowance for the necessary maintenance of the conveyor, other savings through decreased maintenance of trucks and the elimination of wear and tear of truck wheels on the floor almost doubled the expected savings.

In another case, a magnet was installed to handle, sort and pile scrap iron and steel because the work was irregular and labor was hard to obtain. As a result, the capacity of the scrap yard was doubled, enough more loose scrap was piled into a car because it was dropped from a height to pack better, to make a freight saving of $20 per car through loading it nearer the minimum shipping weight, a high labor turnover was decreased and a totally unexpected additional saving of about $1,000 per year made due to the elimination of wheelbarrows, forks and other similar tools no longer required, and their maintenance.

Coal unloading and handling devices, such as portable conveyors and other equipment, often save enough in demurrage charges alone to make them a profitable investment in addition to the decreased labor cost of handling and reclaiming coal, which always results.

Hundreds of other examples of byproduct savings such as reduction of accidents, cleaner products, elimination of breakage, and many others could be mentioned in connection with the installation of newer and more modern methods of handling materials, but these examples show the possibilities.

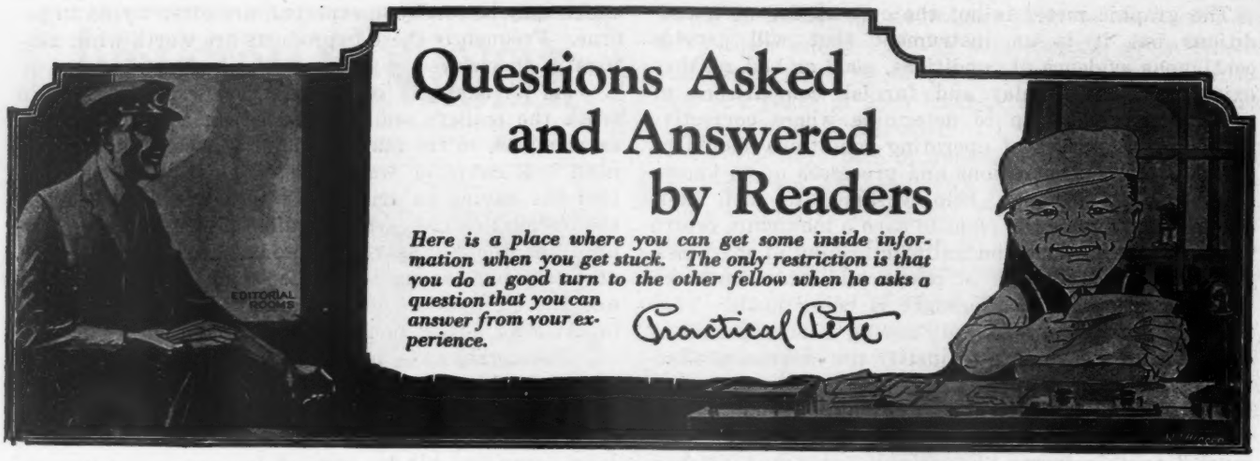
Do You Know So Much That You Can't Learn More?

A MAN who has for many years been foreman of the armature winding department of a large repair shop was recently asked if he had read a certain book dealing with motor repair work. "No, I don't pay much attention to such books any more. I used to read them, but I know the work pretty well now," was his reply.

Without a doubt this man has a thorough knowledge of armature repair work, but his remark may explain why he has not risen above the position of foreman, and in all likelihood never will. He feels that he has learned all there is to know about one phase of a subject and is satisfied to stop there. When a person gets in that state of mind he ceases to grow—and when one ceases to grow the doors of Opportunity begin to close.

Those who know the most about any subject are usually the least willing to say that they know all there is to know about it. In the electrical field particularly, new designs and materials, new methods and ways of doing things are continuously being developed. What is common practice today may have been unheard of ten years ago and in many instances will probably be obsolete ten years from now.

Too much self-satisfaction is a dangerous luxury; it is likely to obscure the need for constant study and effort to obtain more knowledge, skill and experience which are essential to real progress.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Testing and Balancing Small Rotors—I wish some reader of INDUSTRIAL ENGINEER would tell me how to test small rotors for all defects which would cause them to run hot. Will someone also tell me what is the best way to balance a rotor?
Vincennes, Ind. R. M.

* * * *

Methods of Storing Spare Motors—I should like very much to have some of the readers of INDUSTRIAL ENGINEER describe the methods which they have devised for storing motors in such manner as to require the least possible floor space. We have over 200 spare motors ranging in size from ¼ hp. to 85 hp. A crane is available and we can pile as high as twenty feet, but floor space is limited and I must use it effectively.
Media, Pa. A. S. H.

* * * *

Commutator Connections of Two-Pole, Compound-Wound Motor—I should like to see a diagram showing how to connect the starting and finishing ends of coils to the commutator of a two-pole, compound-wound motor, which is rated at ¾ hp., 220 volts, 3.7 amp., 1575 r.p.m. The coils have twenty turns of No. 22 s.c.c. wire. There are twenty-four slots, two coils per slot, and forty-eight bars.
Morrero, La. P. D. H.

* * * *

How Do You Explain Operation of Variable-Speed Induction Motor?—I would like some help from readers of INDUSTRIAL ENGINEER on the following questions: (1) In a variable-speed induction motor how does the rotor cut down the speed when the field is revolving at full frequency speed? Please explain briefly the theory. (2) Why are the slots in a Westinghouse 30-hp. rotor on a considerable slant instead of straight across and parallel to the shaft?
Chicago, Ill. V. L.

* * * *

Preventing Corrosion of Iron Storage Battery Racks—I should like to ask your readers what treatment can be given to iron racks for storage batteries which will prevent the spilled acid from attacking the iron. We use the lead type of battery filled with dilute sulphuric acid. We have a large number of storage batteries and recently some iron racks have been constructed. All of these racks were painted with several coats of the best grade of asphaltum black paint but this does not protect the iron when acid is spilled on it, nor does any kind of paint that I have tried.

We have had considerable trouble due to the corrosive effect of the acid forming a substance resembling sand which falls into the jars below. This produces excessive iron in the solution, making a change of acid necessary. I shall appreciate it if anyone can tell me how to overcome this.
Atlanta, Ga. J. B.

* * * *

Path Followed by Current in D. C. Generator—I wish some reader would show by a diagram the commutator connections and the path followed by the current in a direct-current generator which has two poles, 29 segments, 15 slots and 15 coils with a winding pitch of 1 and 4. The machine has two brushes set at 90 deg. I removed a short circuit from the armature of this machine and afterwards drew a diagram to trace the current. Owing to the winding pitch I failed to get the right direction of current flow for each coil. I have had considerable experience in winding d. c. and a. c. machines but this is the first time that I have seen a machine of this design.
Libby, Mont. J. Q. W.

* * * *

Finding Commutator Pitch of Armature Coil with Test Lamp—I should like to have one of our readers answer the following questions: (1) What is the best and quickest method of finding the commutator pitch of an armature coil with a test lamp? (2) What is the quickest method of stripping a partially-closed-slot armature?
Brooklyn, N. Y. H. C.

* * * *

Operating Two-Phase Induction Motor on Three-Phase Circuit—I should like to know if a two-phase induction type or squirrel cage motor can be run on a three-phase circuit, keeping the same speed and pulling the same load. I should like very much to have someone give me a diagram of such a hook-up and state if the two finishing ends of both phases or the start of one phase and the finish of another are hooked together. On what principles will the motor operate?
Chicago, Ill. J. H. B.

Answers Received To Questions Asked

In the September issue of INDUSTRIAL ENGINEER Edward A. Gibbs, in his comments on a case of motor trouble reported by J. H. M., asks for more data and thinks that there is still something unexplained. Now, I have on various occasions seen motors with reversed fields act in the same manner as described by J. H. M. If the motor is started with the rheostat and given time to come up to speed before all resistance is cut out, it will run with the shunt field, but in case power is cut off and the rheostat handle or lever does not come back to the starting position, when power is put on the line again the motor will have no protection, a heavy current will travel through the winding reversing the armature whether it is loaded or not. The same results will be obtained in case the resistance is cut out too quickly on starting. ELZA HERRMANN.
Middleport, Ohio.

* * * *

Preventing Corrosion of Copper—Will someone please tell me how I can prevent the corrosion of copper parts of equipment that is located in a chemical plant. I have tried everything I can think of, but without success.
Charleston, W. Va. E. B. G.

In the July issue, E. B. G. asks how to prevent the corrosion of copper parts by acid fumes. Copper parts that do not have to be handled often may be covered with a coating of a good grade of vaseline thinned somewhat with gasoline. Parts that are subject to much handling should, however, be coated with orange shellac. A fresh coat should be put on whenever signs of corrosion appear on the copper. I have found that these two coatings will withstand most acid fumes. J. H. GALLANT.
Belleville, Ont., Can.

Removing Insulation from Enameled Wire—I should like to know if any of your readers know of a quick method of removing enamel from magnet wire, other than scraping with a knife. I find it takes a great deal of time for this operation in winding a motor and I would be very grateful if someone can tell me of an easier method.
Avenel, N. J. J. U.

Regarding the query of J. U., in the August issue concerning a quick method of removing enamel from magnet wire, from my experience I have found that the quickest and safest method is to use very fine emery cloth which has been well soaked in alcohol or turpentine.

Both alcohol and turpentine have a very marked tendency to soften the insulating enamel, thus making possible a very clean removal without injury to the conductor itself.

Detroit, Mich. JOHN B. RAKOSKE.

* * * *

In the August issue, J. U., asked if there is a quicker way of taking enamel insulation off of fine wire than by scraping. We have found that by using a fine grade of sandpaper, that is, finer than No. 1, the enamel can be removed cleanly and quickly. The sandpaper is most easily handled by cutting it into strips about 2 in. or 3 in. long and 1 in. wide, and folding it. The wire is then put in the fold and the enamel sanded off. Too coarse a grade of paper will break fine wire before the enamel comes off. We have tried acids and chemicals for removing the enamel but have found nothing of this sort that is safe to use on armatures, especially around commutators. GEORGE D. RINGNESS.

Peoria, Ill.

* * * *

With reference to the question asked by J. U. in the August issue, the coating on enameled wire may be removed very satisfactorily by the use of "Oakite," a compound made by the Oakley Chemical Company of New York, N. Y. A few ounces of Oakite are used to a gallon of water and the solution should be kept near the boiling point for quicker removal. The ends of coils can be suspended in the solution for a few minutes or the wires may be reeled through the solution slowly if the entire wire is to be cleaned. The solution must be washed off in hot water and the wire will then retain enough heat to dry itself.

This company's "Plater's Cleaner" must be used for removing some classes of insulation. Special problems should be referred to the company for their recommendations as to the exact concentrations to use.

The writer uses a large tank of this solution for removing varnish and oil from motor stators after these have been stripped. The stator comes out in 15 min. as clean as a new motor. The cost of this method of cleaning is 75 per cent lower than that of scraping and finishing with gasoline and gives a far better job. The motors are rinsed off with cold water, but enough heat remains in the iron to dry the stator quickly.

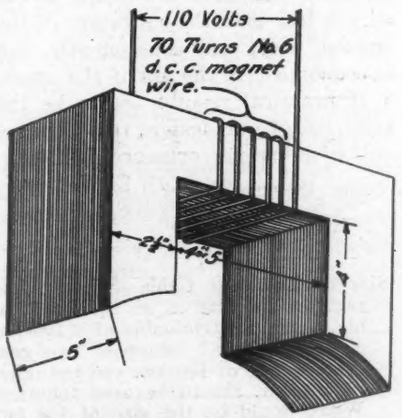
J. ELMER HOUSLEY.

Electrical Engineer,
Aluminum Ore Company,
East St. Louis, Ill.

* * * *

Design of a Growler for Testing Armatures—I wish some of the readers of INDUSTRIAL ENGINEER would tell me how many turns and what size wire to put on a laminated core in order to make a growler for testing armatures up to 50 hp. in size. This core is 8½ in. x 4 in. x 4 in., and has a 1¼-in. slot cut into it. If necessary I could make the core longer. Alternating current of 110 or 220 volts is available for operating the growler.
Canton, Ohio. R. M.

In answer to the question by R. M., in the August issue in regard to the design of a growler for testing armatures up to 50 hp., I wish to submit the accompanying drawing. This drawing shows the construction details of a growler, consisting of a laminated iron core wound with 70 turns of No. 6 d. c. c. wire, which I have made up for my own use and have found very satisfactory for testing railway, elevator and crane motor armatures in our repair shop. I hope this information will be helpful to R. M. and to our many other readers. U. O. MISNER.



Design of growler for testing armatures up to 50-hp. in size.

Pioneer Electric Co.,
Richmond, Calif.

* * * *

In reply to R. M.'s question in the August issue, I am using 4¾ lb. of No. 13 magnet wire, single cotton and enamel insulation, on my testing growler and have found it very satisfactory as it will do all that I ask of it and I have found it suitable also for baking small armatures.

Los Angeles, Calif. J. WOLFE.

* * * *

Locating Trouble in Wiring Circuit—I would appreciate suggestions from readers on the best scheme for testing B X wiring circuits for troubles such as short circuits and grounds, which does not require taking out switches and receptacles or dropping of canopies of lighting fixtures.
Brooklyn, N. Y. H. F.

In answer to the question asked by H. F. in the April issue on locating trouble in wiring circuits, once in a while a good wireman will find trouble on a BX installation when he tests it out at the end of a job. In such cases I trace this out as follows: If both fuses are blown in the service cutout it is probably due to a short before the wires reach the branch cutout fuses, as these latter are smaller and would blow first if the trouble was on a branch line. If one of the service cutout fuses is blown it means there is a ground on that line before it reaches a branch cutout, but if one or more fuses are blown on the branch cutout the ground is inside that point and outside any other fuse that may be still further in, in the line. If the trouble is found to be a ground, the easiest way to locate it is to loosen the BX squeeze fitting and pull out the armored section so as to open up the ground return. It is then easy to find out on which side of the open ground the ground is located. This can be done where the BX drops to the cellar conduit or any other accessible place and by following this out you can tell in which branch it is located.

If you cannot get power you have an open and you will have to try in about the center of the feeders. If you get power there the open is farther away from the service. The cause of most of the opens in BX work lies in the way that the wires are handled during the time that the armor is being cut off and afterwards when the joints are being made. Most of the grounds are found under switch and receptacle plates where the wires go under the screws and the ends touch the plates.

Before testing out for an open in the wiring it is advisable to see that all the fuses are in good condition, as the trouble may be due to a blown fuse from a ground.

A temporary way to fix a circuit with a ground is to reverse the wires at the service cutout, thus putting the ground wire on the grounded side of the system. They must not, however, be left this way permanently because if an open should develop in the ground wire and a fuse blow in the grounded side, a person would get a shock upon touching the piping system. R. M. BEECHER.

Buffalo, N. Y.

* * * *

Rewinding Single-Phase Motor—I have a single-phase Menominee motor that has a main winding of 29 turns of No. 19 wire with two wires in parallel in slots 1 and 7. There are 48 turns in slots 2 and 6 and 49 turns in slots 3 and 5. This is a 4-pole machine.

The starting winding has 12 turns of No. 25 wire in slots 1 and 7; 20 turns in slots 2 and 6, and 20 turns in slots 3 and 5. What I want to know is whether or not this motor can be wound with a single wire and what size will be required to replace the two No. 19 size in parallel. The motor has 24 slots and the nameplate shows 110 volts, 3.8 amp. 1/6 hp., 1750 r.p.m. I have just rewound one of these motors with a single No. 19 wire and it seems to run all right.

Sartell, Minn. L. S.

In regard to the question by L. S. about rewinding a 1/6-hp. 110-volt, 1760-r.p.m. Menominee motor with one wire instead of two in parallel, No. 19 B. W. G. wire has an area of 1,764 circ. mil. Two in parallel make a total of 3,528 circ. mil. No. 16 B. W. G. wire has an area of 4,225 circ. mil and No. 17 an area of 3,364 circ. mil. In order to work the copper as low as possible, it would be best to use No. 16 wire; using the same number of turns the motor will run a little cooler.

L. S. can also wind the running winding with one No. 19, putting ninety-six turns in slots 2 and 6 and ninety-eight turns in slots 3 and 5. For 110 volts connect the winding in parallel; for 220 volts connect it in series.

For the starting winding put twenty-four turns of one No. 28 wire in slots 1 and 7, forty turns in slots 2 and 6 and forty turns in slots 3 and 5. Connect two coils in parallel for 110 volts or in series for 220 volts, the same as for the running winding. P. P. SCRIBAUTE.

San Francisco, Calif.

* * * *

Answering the question by L. S. in the July issue of INDUSTRIAL ENGINEER, concerning the rewinding of a single-phase motor, there is no reason why the motor as rewound should not operate normally in that it is free from distress and with electrical and magnetic quantities well within the limits prescribed by good design and practice. However, it is somewhat wasteful of material because more iron is in use than is needed to carry the flux set up by the new winding. According to the new winding the motor now has one-half the cross-section of copper and twice the ohmic resistance that it had originally. Therefore, the current input should be one-half its former value, and it is to be expected that the rating will be one-half of what it was at first, or 1/12 hp.

If there is sufficient slot space it is possible to rewind this motor with a single wire of twice the cross-section, or, since the area of a No. 19 B. & S. gage wire is 1,288 circ. mil, the new wire size will be $2 \times 1,288$, or 2,576 circ. mil, or a No. 16 wire. But, since the surface area of a single wire of twice the cross-sectional area will be less than that of two wires of one-half the sectional area, the full-load temperature of the machine will be somewhat higher than it was with the two wires in parallel. Also, it might not be possible to use the same number of turns of the larger wire due to the fact that the curvature of the larger wire is less than the curvature of the smaller wire, and consequently, not as economical in the use of slot space.

If practical results are to be the criterion of our design, this winding will give the performance desired.

Chief Electrician, Prairie View State Normal College, Prairie View, Tex. D. L. WAYNE.

* * * *

Size of Equalizer Cable—What is the ratio of the size of an equalizer cable to the positive cable of a 100-kw. d. c. generator? Suppose two generators, one of 100-kw. and the other of 500 kw. are to be used together. What would be the size of the two equalizer cables and how is this size determined?

Lima, Ohio. J. E. B.

In reply to J. E. B.'s question in the April issue of INDUSTRIAL ENGINEER, an equalizer cable is of the same area in circ. mils as the positive cable. Two machines of different ratings may be operated in parallel provided the voltages are the same and the resistances of the series fields are made inversely proportional to the current capacity of the two machines to be connected. Each machine will then take load in proportion to its capacity. The series field can be adjusted by adding extra turns of wire to this circuit, as required. The area of the equalizer cable connecting these machines should be as large as the positive cable of the smaller machine. The circuit breakers on the smaller machine should be set at the rating of this machine in order to prevent overload and damage.

Americus, Ga. B. BELCHER.

* * * *

The following will answer J. E. B.'s question in the April issue, regarding the size of equalizer cable. Although the current carried by the equalizer cable depends upon the compounding and regulating characteristics of the two machines which are operated in parallel, and may not be very large, it is important for the sake of stable operation that the equalizer cable form a path of very low resistance. Therefore, the equalizer cable should, in this case, be just as large as the positive cable of the 100-kw. generator; if it were larger no harm would be done. If the 100-kw. generator is to be replaced later by a larger generator, the equalizer cable should also be replaced by one as large as the positive cable of the smaller of the two generators in parallel.

Des Moines, Iowa. W. E. PAULSEN.

* * * *

Answering the question of J. E. B. in the April issue, regarding the proper size of equalizer cable: The function of the equalizer cable is to keep the drop across the series fields of two or more compound-wound generators the same, so that one of the machines will not have too strong a field and tend to "hog the load." The resistance of the equalizer cable should be low enough to keep the potential at the series field terminals of the two machines practically the same, and, therefore, the size of wire might have to be larger if the machines were some distance apart than if they were close together. As J. E. B. does not give the voltage of the two machines there is no way of knowing the normal current through the series fields or the probable drop across them. One rule, however, is to make the wire large enough to carry safely one-half of the full current of one of the generators. When the two generators are of different size this would mean that the load of the larger one would have to be considered when figuring out the proper size of equalizer.

It is not often that two machines of so great difference in size are worked together, as their character-

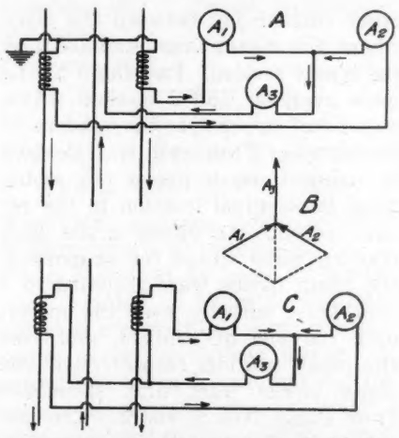
istics have to be considerably alike. Also the resistances of their series fields should be inversely as the amount of current passing through them in order for the drop across the two fields to be the same.

Westfield, N. J. G. H. MCKELWAY.

* * * *

Ammeters Connected for Three-Phase, Three-wire Circuits—I wish some reader of INDUSTRIAL ENGINEER would give me a wiring diagram of three ammeters used on a three-phase, three-wire circuit, using only two current transformers, and explain how current passes through each meter.
Haledon, N. J. G. Z.

Answering the question asked by G. Z. in the August issue as to how ammeters should be connected for a three-phase, three-wire circuit, in the illustration *A* shows the diagram of the connections. It should be noted that ammeter A_3 is in the return circuit from ammeters A_1 and A_2.



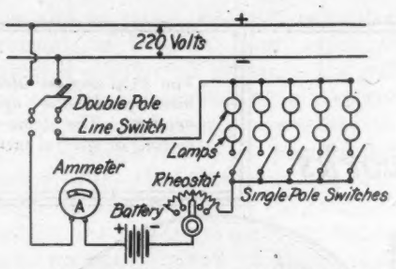
Correct and incorrect method of connecting three ammeters on three-phase circuit.

The vectorial relation of the circuits is shown in *B*. It will be noted that the three currents are fundamentally at 120 deg. to each other; hence the resultant of A_1 and A_2 will equal A_3. This reasoning applies whether the currents are balanced or unbalanced in A_1 and A_2. Should the connections of one transformer be reversed, for instance that for A_1, the current shown by A_3 will be $\sqrt{3}$ times the current in A_1 or in A_2 if balanced. In other words, with 5 amp. in A_1 or A_2, A_3 would show 8.66 amp.

C. OTTO VON DANNENBERG.
New York, N. Y.

* * * *

Charging Storage Battery—I would like to charge the storage batteries in our plant from a 220-volt d. c. exciter circuit of our 2,300-volt a. c. generators. If some readers will show a diagram of connections and a practical method for reducing the voltage, I will appreciate it.
Amenia, N. Dak. J. P. C.



Method of charging storage battery from 220-volt circuit.

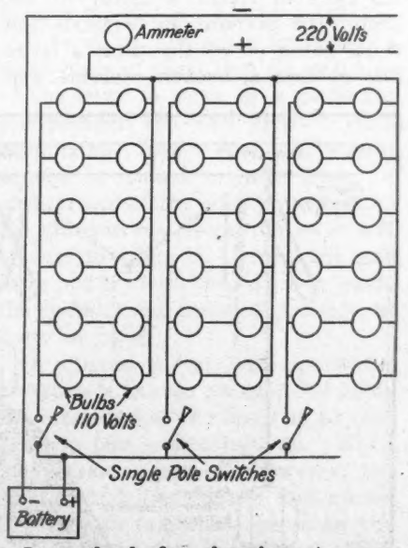
Regarding J. P. C.'s query on battery charging, the diagram shows a simple method that can be used successfully on d. c. circuits for charging small cells.

The current is controlled by a lamp bank consisting of five sets of lamps in parallel with two 110-volt lamps in series per set. By using various sized lamps a very flexible control of voltage is obtained, with still finer adjustments made by the rheostat. Using 110-watt lamps and with all single-pole switches in, approximately five amp. will be obtained. To reduce current cut out sets of lamps or reduce size of lamps used. J. B. RAKOSKE.
Detroit, Mich.

* * * *

In answer to J. P. C.'s request in the March issue of INDUSTRIAL ENGINEER for a method of charging storage batteries from a 220-volt exciter circuit, I am enclosing a diagram which I think will be satisfactory. This diagram shows only a few lamps, but as many may be used as are necessary to get the right amperage through the battery. If there are several batteries connect them in series.

This hook-up was used in a shop



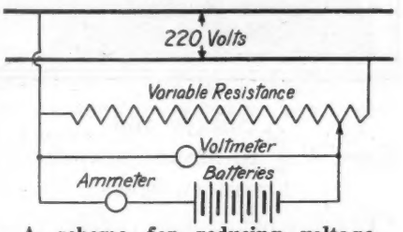
Lamp bank for charging storage batteries from 220-volt line.

where I worked, and proved very satisfactory for charging two and three batteries at a time. The only difference is that we used a 110-volt d. c. system instead of 220 volts, and, of course, had one lamp in the place of two. I think the same results would be obtained if connected as shown.

By the use of the single-pole switches at the bottom of the board as shown, the resistance can be controlled as desired. I might also mention that we used 100-watt carbon lamps. D. S.
Providence, R. I.

* * * *

The accompanying diagram shows an arrangement that can be used to charge storage batteries as mentioned by J. P. C. By this method the voltage can be reduced to any desired volume. H. H. DUNCAN.
Brooklyn, N. Y.



A scheme for reducing voltage when charging storage batteries.

* * * *

In the March number of the INDUSTRIAL ENGINEER, J. P. C. asks how to charge a storage battery from a 220-volt exciter. He does not mention the voltage of the battery, but if it is much less than that of the exciter, he will have to put sufficient resistance in series with the circuit to cut the flow of current down to a safe amount, that is, to the proper charging rate of the battery. If he should desire to charge the battery at the same time that the generator is being used as an exciter, it would be best to have an adjustable resistance in order to control the charging current, because then the field circuit of the generator, and consequently its potential, could not be altered.

To charge, the positive side of the generator should be connected to the positive side of the battery through the resistance and also through a switch and either a fuse or circuit breaker. Then the amount of current supplied to the battery can be controlled by altering either the amount of the resistance or the field strength of the generator.

Westfield, N. J. G. H. MCKELWAY.

SERVICE
around the works

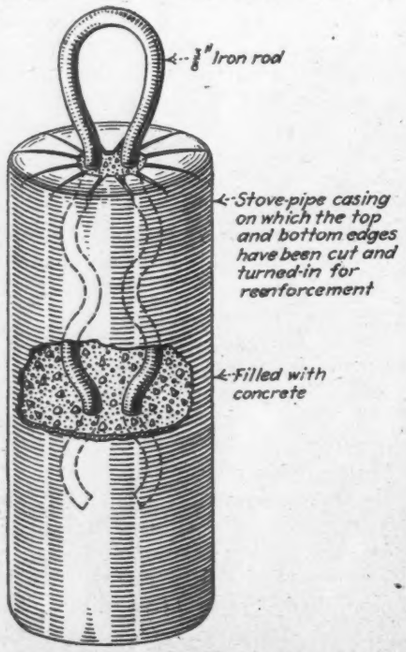
For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

A Simple and Easy Way to Make Inexpensive Counterweights

THE type of counterweight used for the safety gates at the entrance to car lifts in a large garage may be employed in various places. Each of these weights is a concrete cylinder cast in a sheet-metal enclosure. In this case the sheet metal used was a length of 6-in. black-iron stove pipe. To provide a means of attaching the cables, ⅜-in. iron rods were bent and placed in the cylinder before the concrete was poured. The edges of the casing were turned in to reinforce the cylinder and keep the concrete from crumbling at those points where the weights most frequently strike.

With this method of casting the weight to suit the requirements, it is possible to vary the diameter and length so that a weight exactly suited to the needs is obtained without delay or special facilities for casting and cutting off or adding extra material. Materials for making the weight should be weighed in the dry state as this is the condition that obtains when the concrete is hard.

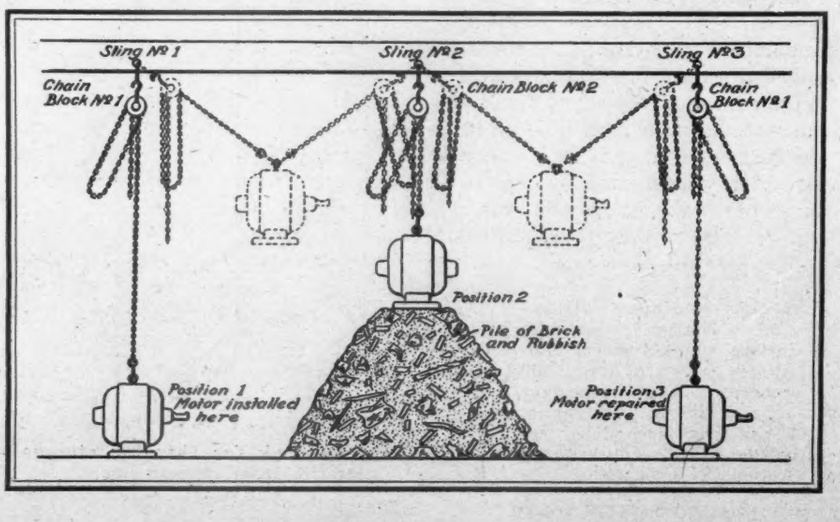
Washington, D. C. G. A. LUERS.


⅜" Iron rod
Stove-pipe casing on which the top and bottom edges have been cut and turned-in for reenforcement
Filled with concrete

This counterweight is made of a piece of stove pipe filled with concrete.

Easy Method of Moving a Motor Over an Obstacle

SOME time ago it became necessary to repair a motor in the shop. On account of construction work going on at the time, a large pile of bricks, broken concrete and other rubbish lay between the place where the motor was installed and the repair section. Two chain blocks were available and a method which may be of interest to the readers of INDUSTRIAL ENGINEER was devised of using them to move the motor from its original location to the repair section. As shown in the illustration, three slings for supporting the chain blocks were fastened to a roof truss directly over the motor, over the pile of rubbish, and over the repair section, respectively. The chain blocks were first suspended from slings Nos. 1 and 2. The motor was then raised several feet from the floor by No. 1 chain block, after which the hook of No. 2 chain block was placed in the lifting ring of the motor alongside of the hook of No. 1.



By means of two chain blocks the motor was first placed on the pile of rubbish and then transferred to the desired location.

As the chain of No. 1 block was slackened off, the chain of No. 2 was tightened with the result that the motor was easily deposited in position 2, on top of the rubbish pile.

Chain block No. 1 was then removed and suspended from sling No. 3 and its hook placed in the lifting ring of the motor, as before. As the chain of No. 2 block was slackened, the chain of No. 1 was tightened so that the motor finally was suspended several feet from the floor, on the chain of No. 1 block. The hook of No. 2 block was then removed and the motor lowered to position 3, where we could do the necessary repair work more easily than would be possible if the motor were kept in its original position.

This same method of handling was used later to place a heavy rheostat on its support over a rather deep switchboard. HENRY MULFORD.

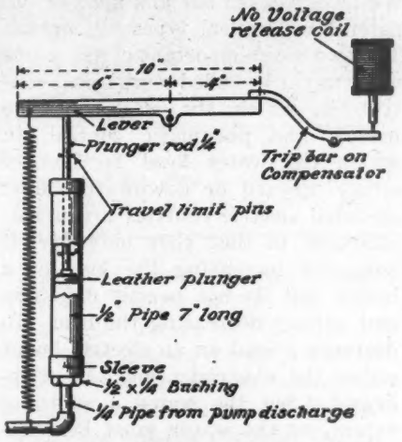
Electrician,
Patchogue Electric Light Co.
Patchogue, N. Y.

Lighting up of Signal Lamp Indicates When the Pump Accidentally Stops

IN THE January, 1923, issue of INDUSTRIAL ENGINEER, Mr. A. J. Dixon described on page 57, under above heading, a device for indicating when a centrifugal pump for any reason ceases to deliver water. A centrifugal pump in our mill lost its suction one day and when the watchman, who makes his rounds every half hour, noticed the trouble the pump was hot and smoking. The motor was still running, but no water was being delivered. All of the brass inside of the pump was burned out and we had to get along without the pump for three days.

To prevent this happening again, I made a device similar to the one described by Mr. Dixon except that instead of using a red lamp I connected the no-voltage coil to the bar supporting the water bucket. Water ran into the bucket through a small pipe and out again through a smaller hole in the bottom of the bucket. So long as the pump delivered water the bucket held the arm down and made the contact for the no-voltage relay. When the water stopped flowing the bucket soon became empty and the arm rose, breaking the circuit in the relay and thus stopping the motor.

Later I made another device which I feel is more satisfactory, for stopping the motor. This device is simple and, as shown in the illustration, consists of a 10-in. lever which is pivoted slightly off center. One end of the lever is raised by a plunger rod in a small cylinder connected to the discharge side of the centrifugal pump, while the other end is in contact with the trip bar of the compensator. As will be seen, the cylinder was made of a piece of ½-in. pipe 7 in. long. A piece of seamless brass tubing would probably make a better cylinder, but I did not have any at that time. The pipe was filed smooth on the inside and the ends fitted with sleeves. A ½-in. x ¼-in. bushing was screwed into one sleeve in order



When the plunger rod goes down through failure of water pressure the lever drops and operates trip.

to connect the cylinder at the bottom to the ¼-in. pipe leading from the pump. The sleeve on the upper end of the cylinder was cut in two and then filled with babbitt and bored to receive the ¼-in. plunger rod which was threaded at the lower end. The plunger was made of leather and was held on the plunger rod by a nut.

I found it advisable to fasten a small piece of sheet iron on each side of the lever to serve as a guide for the plunger rod and keep it from slipping off. Also, a spring or weight should be placed on the inner or plunger end of the lever so that when the plunger rod drops the lever will be sure to follow it. Two small pins were put through the rod, one inside the cylinder and the other outside, to limit its travel.

In operation, so long as water pressure is on, the plunger rod holds the inner end of the lever up so that the trip bar is also held up. When the pressure goes off, however, the plunger rod drops down and allows the lever to fall, thus operating the trip and stopping the motor. This device is positive in its action and has given satisfactory and reliable service. F. G. BONN.

Hammond, B. C., Canada.

Practical Points on The Operation of Electric Steam Boilers

IN THE August issue of INDUSTRIAL ENGINEER I read with interest the article on electric steam boilers by P. H. Falter. There are, however, some details not mentioned in this article regarding the operation of these boilers on which I would like to get more information.

What percentage of moisture does the steam carry on leaving the boiler while operating with a high water level?

On page 404 in the first column the following comment is made: "No chemicals should be added to the feed water for electric boilers." Are the chemicals ordinarily used in boiler feed water detrimental to the electric boiler?

Does scale form on the electrodes and if so, what effect has it and how can it be prevented or removed?

I understand that superheaters and automatic electric control are being developed for electric boilers. How do they operate?

Smooth Rock Falls, Ontario, Canada. W. A. PLANT.

* * * *

NOTE: The above questions were submitted to Mr. Falter and his reply follows.—EDITORS.

The percentage of moisture in steam from electric boilers varies according to the design of boiler employed and to a certain extent to the character of the water. Where very dirty waters are used, there may be a tendency to foam as there would be if such water were boiled with heat from any other source and the percentage of moisture carried over would then be higher. We find, in actual practice, that the percentage of moisture carried over in electric steam has never reached 5 per cent, and as electric steam can only be used for heating purposes, since it would manifestly be absurd to use it for power purposes, the amount of moisture is not objectionable, because the electric boiler is generally placed close to the apparatus in which the heat from the steam is used. Superheaters are, therefore, not necessary unless they would be necessary for any other style of boiler in transmitting the steam unusually long distances.

An attempt has been made to superheat electric steam with electric steam, the principle in brief being to have an electric boiler generate steam at a high pressure and pass it into a heat interchanger through the coils of which part of the electrically-produced steam is admitted under low pressure through a pressure-reducing valve. The low-pressure steam, therefore, takes up heat from the higher-pressure steam and is thus superheated. Manifestly, no great degree of superheating can be obtained in this manner so that where superheating is required, it should be provided either through the ordinary form of superheater or in a separate chamber independently heated electrically to give the desired degree of superheating.

Generally speaking, a feed water which is satisfactory in a fuel-fired boiler may be used in an electrode-type boiler. What I meant by saying that no chemicals should be added to the feed water for electric boilers is that no attempt should be made to hold the resistivity of the water in the boiler at any desired point by the introduction of chemicals. The resistivity of electric boiler feed water or rather the water after it has entered the electric boiler can be well enough controlled by the proper methods of operating an electric boiler of this type.

European practice some years ago, and even to this day to a certain extent, requires the use of a "doper" with which to doctor the water within a boiler to hold its resistivity at some predetermined figure, but American and Canadian practice has from the very beginning discouraged doping in any form, since as already stated, the boiler can be operated satisfactorily after it has been properly designed for a water in a given district. Even uncontaminated or untreated waters vary greatly in different parts of the country, so that electric boilers must be properly designed to suit the water in any given locality.

The qualities of the water also have much to do with the amount of scaling of electrodes and boiler shell, just as in the case of any other kind of boilers, but scales can be removed much more readily from the electric boiler than from an ordinary tubular, fuel-fired boiler. Ordinarily the entire head of a boiler can be removed and, except for the smallest sizes, a man can get right down into the boiler shell with a hammer and break scale loose. The electrodes are generally attached to the head of the boiler so that when the head is removed the electrodes are in full view and readily accessible for removal of scale. The effect of scale on electrodes is generally to insulate them so that they will carry less and less current, thus reducing the capacity of the boiler in time and requiring the removal of the scale in order to put the boiler back into satisfactory, full-load operating condition.

As to automatic control of boilers, the writer personally, and also his company, has done much to provide for almost any given requirement. We have worked out and applied for patents on several types of control. The two most important of these are what might be called mechanical control, in which the electrodes are moved, and pneumatic control, in which the water level is changed either upward or downward. Most so-called electric controls are unsatisfactory in that they only permit definitely increasing the load of a boiler, but do not permit definitely and quickly decreasing the load. To decrease a load on an electric boiler either the electrodes must be withdrawn from the water a sufficient extent, or the water must be withdrawn from the electrodes; that is, the water level must be changed.

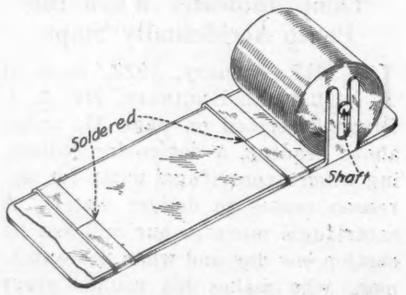
It is not desirable to waste the hot water in a boiler and for this reason our pneumatic method was perfected. It is now possible to change the load which a boiler carries at any reasonable rate and thus to cause an electric boiler to take on surplus power and to automatically release such power when a mill again requires it, thus keeping the load factor of a system at or very near 100 per cent. This is very important since load factors often are as low as 30 per cent, as in steel mills, and are seldom much above 80 per cent unless we are considering electrolytic loads. Power is frequently bought to meet a maximum demand, but very few loads are constant. Therefore, anything that can be done with the power between the normal load factor and a 100 per cent load factor, reduces the cost of power paid for but not used. Wherever there is a use for steam or even hot water the electric boiler supplies an excellent way of using such surplus power to advantage.

Controls may be effected by a totalizing watt-meter, by a steam gauge or by the changes in frequency of a system, in any of these cases, however, causing the electric boiler to automatically take on or to release power, as the case may be, thus maintaining a load factor very close to 100 per cent. Where it is only necessary to maintain a steam pressure irrespective of power supply, a very simple method has been developed for causing the electric boiler to automatically follow the steam demand.

P. H. FALTER.
Electric Furnace Construction Co., Philadelphia, Pa.

How to Make a Holder for Desk Memorandum Roll Paper

MEMORANDUM pads in roll form are handy for desk use, as the paper can be torn off in any desired length, according to the extent of the memorandum. Rolls of paper for use in a holder are obtainable in widths of 4 in. to 6 in. and the outside diameter of the roll is about 5 in. The holder is formed from sheet metal and can be made as

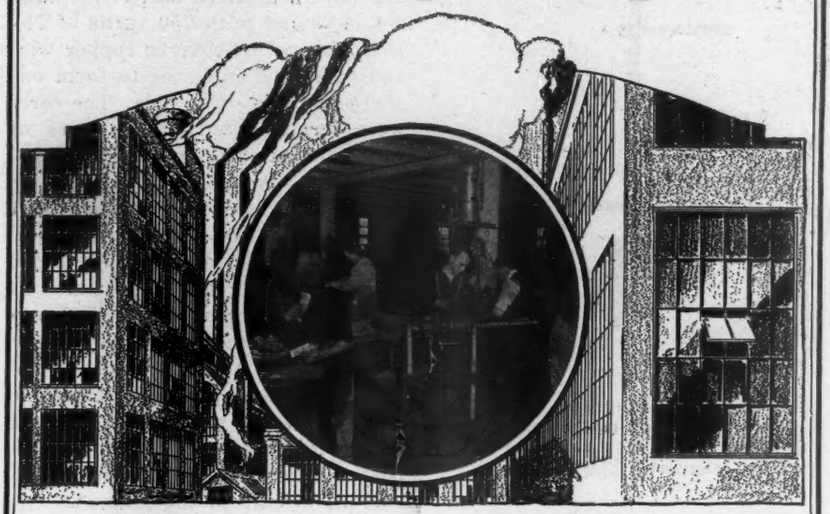


Paper is torn off according to length of memorandum written.

elaborate as desired. For a simple holder the design shown in the accompanying illustration is recommended as a sturdy and durable type. A large number of these have been made for use in the offices of a local machinery plant. The holder is in one piece, cut from sheet brass of the shape shown in the developed plan. It is then bent and the strips across the holder are joined with solder. The vertical parts serve as guides for the shaft supporting the roll of paper. The rear cross strip is beveled as a cutter to facilitate tearing off the memorandum. In the case of the holders made for office use, the owner's initials were stamped on the cutting strip and the holder was nickel plated, thus making a neat individual accessory for each desk worker.

G. A. LUERS.
Washington, D. C.

In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

How to Make a Simple Washer Cutter for Use At the Bench

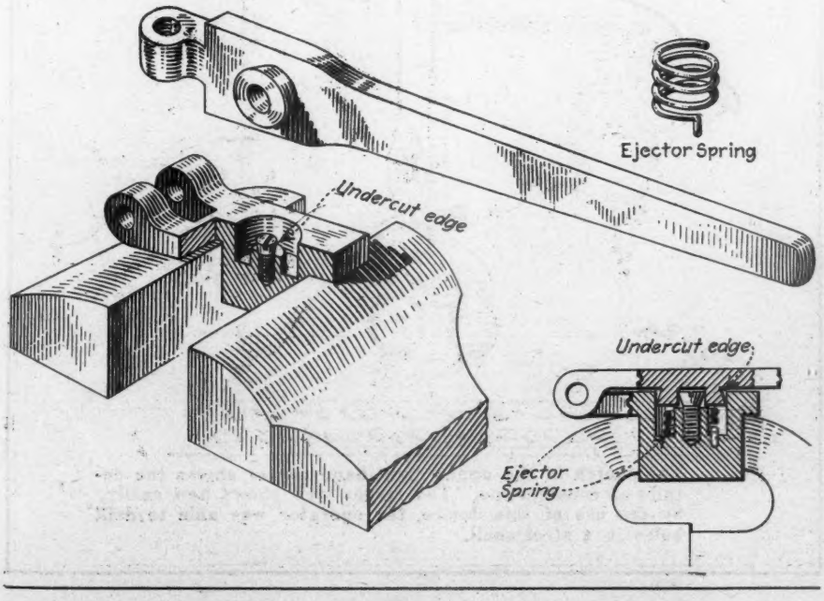
THE SPECIAL cutting fixture shown in the accompanying sketch can be used for cutting various sizes of leather, composition rubber, fiber and sheet-metal washers. Every maintenance man knows how frequently these washers are required. With a cutter such as this a number of each size may be made up in advance.

Differing from the usual types, this fixture has no separate dies nor does it require the use of a hammer or press to operate it. The simple operation of pressing the lever makes a finished washer in this one movement. The fixture as illustrated is held in the jaws of a vise and an extended hand lever furnishes the means for obtaining a heavy pressure at the cutting edges of the die.

The lower section is a steel forging, with a block or lug for the vise jaws. The die recess is sunk into the forging and has a tapped hole for a center punch to cut the hole in the washer. The spring serves to eject the cut washer. The upper section of the cutter embodies a handle, extended cutting edge and hinged member to correspond to the lower section. The cutters are tempered to hold the cutting edges. Sizes are not shown in the sketch, as these depend upon the required washer sizes.

Washington, D. C. G. A. LUERS.

Washers may be easily cut from fiber or other material with this device.

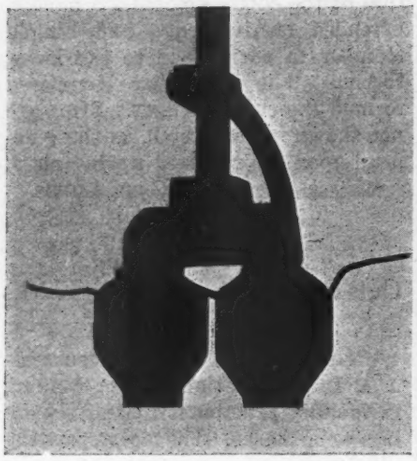


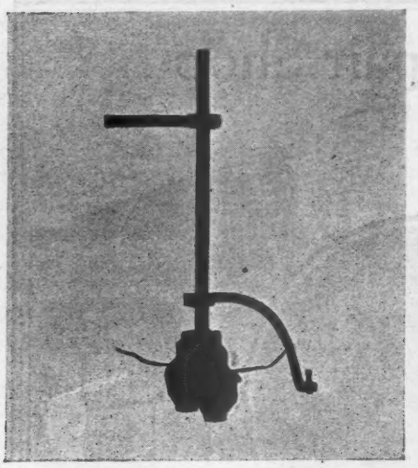
How Arc Welding Cuts Repair Costs on Worn Flasks in the Foundry

AN INTERESTING and successful application of arc welding in foundry practice is that of repairing worn flasks. The accompanying illustration shows a pile of flasks which have been repaired by the arc with the exception of the one in the foreground. The upper malleable iron lug on this flask shows that the hole in it has been worn until the pin on the other half of the flask will not fit in it tightly enough to hold the parts in sufficiently good alignment. The practice in the past when making repairs has been to ream out the hole to 7/8 in. and then press in a 5/8 in. bushing. When the bushing wore too large it was replaced with a new bushing.

The new method of repair, however, is less expensive and much more satisfactory. The practice now is to ream out the hole to 7/8 in. and then fill the hole completely using the metallic-electrode, arc welding process. A piece of copper is placed under the hole and the welding is made by using about 175 amp. and

Pile of flasks repaired by the arc welding process as described in the accompanying item.





These two photographs show a close-up view of the magnet foot (at the left) and a complete view of the magnetic "old man."

5/32 in. welding wire. About three minutes are required to weld a hole.

When these holes are again worn oversize it is not necessary to ream them out before the welding operation. The time required to weld a hole is then reduced to about two minutes. The cost of welding each hole as originally drilled to 7/8 in. diameter is about as follows:

Labor at 70 cents per hr.....	$0.035
Welding wire at 8 cents per lb...	.016
Electric power at 3 cents a kw-hr.	.013
	$0.064

The question naturally arises as to why it is necessary to drill a 7/8-in. hole in the casting when only a 5/8-in. hole is required for the pin on the flask. The reason for this is that there will be a layer of hard, chilled, high-carbon cast steel about 1/16 in. thick in the region where the deposited metal unites with the casting; therefore it is necessary to have the original hole 1/4 in. larger in diameter than the final hole so that no difficulty will be experienced in drilling the final hole through the deposited metal.

A. M. CANDY.
General Engineering Department,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

Drilling Holes on Surface of Large Cylinder with a Magnetic "Old Man"

IT BECAME necessary when making some repairs, to drill about 1,500 holes (5/16 in. or 3/8 in.) in some 1 1/4-in. boiler plate shells 19 ft. in diameter and 65 ft. long. A portable electric drill was available, but the difficulty of applying the pressure is readily realized. The magnetic "old man" illustrated in the accompanying sketches and photographs made the operation a most simple one. The spherical shape of the ends of the shell required the planes of the faces of the magnet to be adjustable. In addition it was designed to be built of easily available material.

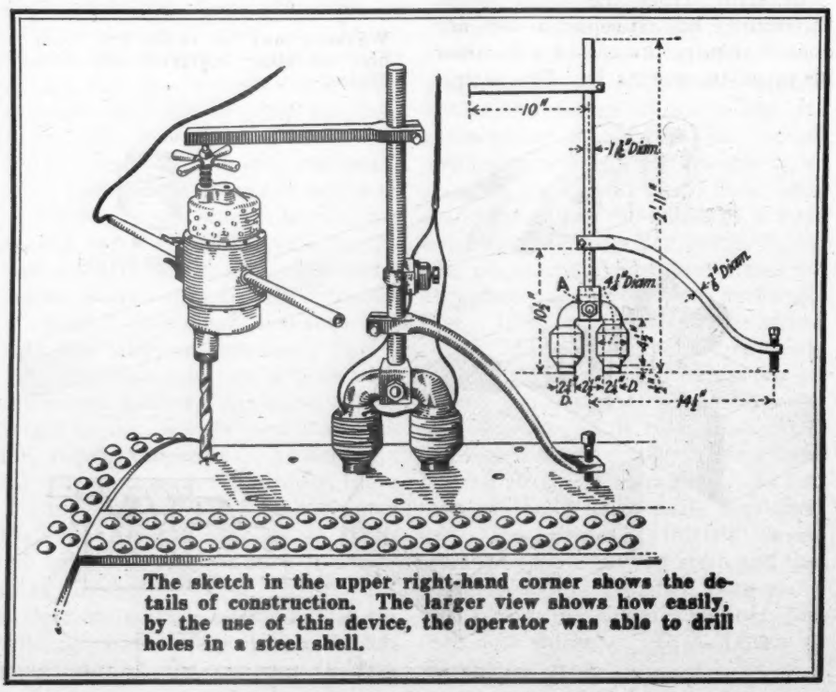
Of course, the first hole might be forced through the shell and then the ordinary type of "old man" bolted on. That, however, would have required considerably more time to move and adjust into position than did this which merely required turning the current off, moving into position and turning the current on again.

A horseshoe magnet was forged to the approximate dimensions shown in two similar parts, from 2 1/4 in. round iron; this was machined and hinged at *A* to maintain a full cross-section. The pole faces of the core are machined. Each half of the magnet is wound with 750 turns of No. 16 double cotton-covered copper wire and connected in series to form one north and one south pole. The cores were wrapped with two layers of varnished cambric and the coils covered with a wrapping of cotton tape, impregnated by immersion and later varnished. A yoke of 1/2-in. by 2-in. iron was forged to enclose the hinge of the magnet and a 3/4-in. bolt clamps the joint securely. The post is 1 3/16-in. round, cold-rolled steel; the rear leg and the bracket are forged, drilled and split to clamp on the post in any position. A tumbler switch is conveniently secured to the post to open and close the direct-current circuit to the magnet.

A supply of direct current is available and, with part of a heater element as an external resistance, 24 volts are impressed on the magnet winding, producing a current of 3.8 amp. The coils will carry 5 amp. without overheating. The coils could have been wound to resist full direct-current voltage, but No. 16 B. & S. gage wire was the smallest on hand.

The magneto-motive force generated is ample to overcome the reluctance of paint and irregularities on the surface. When better contact is made the magnetic density is increased and the tractive force becomes much greater.

Smooth Rock Falls, Ont., Can. W. A. PLANT.



The sketch in the upper right-hand corner shows the details of construction. The larger view shows how easily, by the use of this device, the operator was able to drill holes in a steel shell.

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

How the Proper Design of the Equipment Affects the Economical Handling of Material

THE INFLUENCE of design upon the ease and speed as well as the economy of handling materials is well shown in the following extract from a report on "Single Bucket Blast Furnace Skip Hoist Characteristics" by A. C. Cummins and A. R. Leavitt of the Carnegie Steel Company given before the Buffalo Convention of the Association of Iron and Steel Electrical Engineers. Investigations were made on the most economical type of hoisting equipment, but it was soon seen that improvements in motoring alone would not give the full benefit expected.

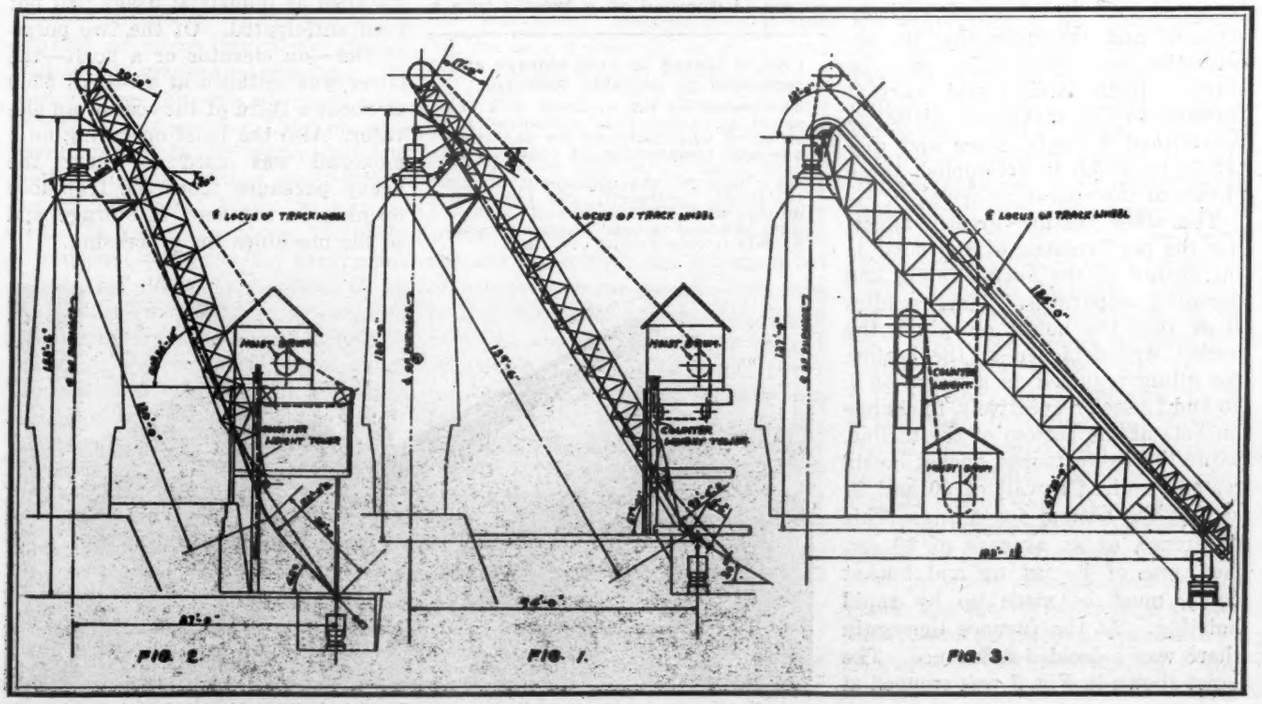
It was found in making time studies that the incline design as well as the arrangements for loading and dumping the buckets could so affect the efficiency of a hoist as to nullify the results obtained from a carefully designed hoisting equipment, from the standpoint of efficiency in the use of power.

The majority of blast furnaces are rated at from 500 to 600 tons of pig iron produced per 24 hr. Nearly all of them use about the same raw material; hence, when considering the work accomplishment of blast furnace hoists, the duty cycles are in most cases not radically different. Figs. 1, 2 and 3 show incline designs of hoists on which tests were run. On casual inspection they seem closely similar, but they are quite different when performance of the hoist operation is considered.

The incline shown in Fig. 2 imposes the greatest handicap of the three upon the hoisting equipment. It will be noted that the first 30 ft. of the incline are at an angle of 45 deg., the next 130 ft. at an inclination of 68½ deg., while the final 20 ft. are at an angle of 20 deg. Each time the angle of inclination of the hoist changes there is a difference in the horizontal and vertical component of bucket velocity and in the relation of each to the other. If the changes in components of the velocity occur too rapidly, bucket oscillations are produced. In the case of

One of these inclines can be operated more economically than the others.

One of three designs of inclines for blast furnace skip hoists can be operated with motors of 100 hp. less capacity as explained in the text. This is only one example which shows that whenever a study is made of material handling methods it pays to make it thorough and include every detail of equipment design and operation.



the particular hoist shown in Fig. 2 this feature of the design of the incline necessitates operating the hoist at reduced speed past both points of change of incline slope. Such a condition imposes a severe handicap on the performance of the hoisting equipment for a number of reasons.

(1) So much time is consumed in passing over the slow-speed portion of the incline that the maximum speed must be made excessively high to compensate for the time so lost. The motors must, therefore, be larger, the peak power demand is higher and rheostatic losses greater.

(2) High ratio of high speed to low speed gives poor torque characteristics on some types of hoist, even though field control is used. At one plant the operators frequently must operate the magnetic controller by hand in order to pull buckets that are stuck on the incline on that account.

The incline design shown in Fig. 1 is an improvement over that shown in Fig. 2, in that the distance from the top and bottom of the incline to where the changes in angularity are made are reduced, chiefly at the bottom of the incline. The reduction amounts to 21½ ft. at the bottom of the hoist and 3 ft. at the top. This decreases the time on low speed, and hence will permit the use of lower maximum speeds and the advantages automatically gained thereby.

In Fig. 3 we have an incline design which is vastly superior in contour to those in Figs. 1 and 2. It will be noted that it is almost entirely straight, and, therefore, that the acceleration and deceleration may be started immediately, and carried through to the maximum limits as determined by safe rates and distances in which to accomplish these phases of the operating cycle.

The other feature greatly affecting the performance of the hoist is the design of the bucket filling and dumping apparatus. Time studies show that the hoists on which the bucket was detached at the bottom for filling required an average of 6, 10 and 12 sec., respectively, to change buckets at the bottom of the incline, while the two attached bucket hoists tested required a wait of 30 and 32 sec. at the bottom for filling. This difference, or an average of 20 sec. per cycle of bucket up and bucket down, must be made up by rapid hoisting. At the furnace top again there was a decided difference. The hoist shown in Fig. 3 was stopped at the top of the incline for an average of a little less than 3 sec. while dumping. As compared to this the other hoists used 12, 17, 18 and 26 sec., respectively. It would, therefore, seem that a hoist using only 3 sec. at the top for emptying the bucket represents a great time saving. The results of the time saving on the part of hoist in Fig. 3 enabled it to hoist a round of material in approximately the same time as that shown in Fig. 2 with motors of 100-hp. smaller rating, and at a maximum speed of 370 ft. per minute as compared to 508 ft. per minute.

How Two Men Supplanted a 12-Man Yard Gang for Handling Coal

STORAGE and reclamation of coal is an important feature of yard work in many industrial plants. Because of its intermittent nature this work continually results in frequent hiring and discharge of men and causes a high labor turnover. Plants which have sufficient other yard work to keep these men busy between coal receipts are relieved of this difficulty, but nevertheless have the considerable item of expense for this work and also usually are required to maintain a gang larger than would otherwise be required.

At the Chicago plant of the Mechanical Rubber Company the storage and reclamation of coal is done by a conveyor. Here the coal as received is dumped on a trestle into a hopper from which are filled small dump cars which run on a track from the hopper into the storage yard. These dump cars are pulled up to the top of the pile by a cable and pushed to the part of the pile where it is desired to store the coal. Here they are dumped at the foot of a portable belt conveyor (Barber-Greene Company, Aurora, Ill.) which carries the coal away from the track and spreads it on the pile, as shown in the accompanying illustration. This eliminates moving the track as well as all wheeling and enables two men to do what previously had required a yard gang of a dozen or more men.

This same track also runs into the boiler room and in reclaiming coal the conveyor is turned around and used to reload the dump cars which are pushed into the boiler room and dumped. In this way the portable belt conveyor is kept busy most of the time. Meanwhile, it saves the wages of ten or more men.

Coal is spread in yard storage and reclaimed by portable conveyor.

The wages of ten or more men are saved by using this equipment instead of wheelbarrows for the storage and reclamation of coal. With such a saving as this it does not take long for the equipment to pay for itself. Ordinarily, two men now do this work but occasionally a third man is added in case a large number of cars is received at one time.

Using Second Floor for Storage With Electric Hoist

MANY CONCERNS must adapt to their own needs buildings already constructed where the handling of the material is one of the most difficult problems. For example, in one small plant it became necessary to use a second floor for the storage of heavy material. Previously this space had been used as an office and an elevator had not been installed as industrial usage had not been anticipated. Of the two possibilities—an elevator or a hoist—the latter was installed at a cost of $500 or about a third of the cost of an elevator. Also the hoist operating on a monorail was used to carry the heavy packages from the trap-door opening in the floor to storage and to the machines for processing.

Problems of Steel Mill Operation

(*Continued from page 484.*)

F. W. Cramer spoke of the success he has had with magnetic clutches on centrifugal pumps which start and stop frequently. Formerly he operated these pumps from a control panel equipped to start and stop the motor when the water flow was started and stopped. This resulted in frequent motor burnouts. Since installing the magnetic clutches a year ago, he has had no burnouts and has not replaced the clutch lining.

In speaking on this subject, H. D. James, Westinghouse Electric & Manufacturing Company, emphasized the point that it is often better not to stop the pump or motor when the water valve is closed, but to allow the pump to churn the water. Of course, under this condition some power is consumed, although it is little compared with that used while pumping against the normal head. Moreover, the saving in wear on the motor and controller will often be much greater than the cost of the extra energy consumed.

He also mentioned the advantages of the self-starting synchronous motor for pump drive. The starter for such a motor is simple, automatic priming is easily accomplished, and bearing thermostats are readily applied. Incidentally, Mr. James mentioned that there is a popular misconception regarding the benefits of correcting power factor with small synchronous motors. He stated that the use of small synchronous motors for this purpose would prove to be expensive and quoted the case of one plant where the motors were 100-hp. in size or less. To raise the power factor to a reasonable figure in this plant would cost 20 cents per kw. if all the induction motors were replaced by synchronous motors. Only 7½ cents per kw. would be required to accomplish the same result by using induction motors and installing a large synchronous condenser to float on the line. The same results might be accomplished in a similar case by installing static condensers.

Mr. Cramer said that the advantages of electric drive for pumps are more prominent as the distance from the pumps to the source of supply becomes greater. He said that his company had some pumps in a mine which were originally fed by a long steam line. Motor drives were substituted and paid for themselves within one year by their savings.

The danger of overloading a centrifugal pump drive by decreasing the working head was mentioned by Mr. Kennedy, and two other speakers cited experiences which bore out his contention. Mr. Hipple told of a case in which a pump had been delivering 18,000,000 gal. in 24 hours. The motor ran hot and the windings frequently became brittle. It was found necessary to increase the amount of water delivered to 20,000,000 gal. per day. Since this was done the motor has been operating at a lower temperature and has never required rewinding. A. C. Cummins spoke of a similar case in which the intake to a centrifugal pump was accidentally obstructed by a block of wood. The pump had been delivering 15,000,000 gal. per day, but after the intake was partially closed by the block, the delivery increased, due to the fact that the operating head was increased and permitted the pump to operate at a higher point on its efficiency curve. As an experiment, the delivery end of the pump was also partly obstructed, still further raising the head. The delivery then increased still further to 18,000,000 gal. and the motor temperature was not raised at all.

In the discussion on the hazards of ore bridges of the skew type a practical point was mentioned by Mr. Eastwood. He told of a bridge which was driven by a spur gear that engaged a rack mounted parallel with the track. The spur gear was in turn driven by a motor through a self-locking worm gear. This arrangement assured a positive control of the bridge movement, despite slippery rails and so on. Another speaker questioned the statement of Mr. Canney in his paper, which was to the effect that rail clamps should never be applied while the bridge is in motion. He said that this statement holds for the self-locking cam type of clamp, but that at least five other types can be applied without danger. These clamps take hold of the rails gradually and when at their final position their braking force is less than the force required to overturn the bridge. He also warned that the anemometer described by Mr. Canney would give no protection against excessive wind velocity in case of an accidental opening of its electrical circuit, as it requires a closed circuit for operation.

Mr. Farrington recommended that the brakes on ore bridges be arranged so that they will be actuated by compressed air, counterweights or other means in order that they will not fail to operate in case the power is accidentally cut off.

Regarding electrification of foundry equipment C. S. Carmen said that electric power is most suitable for handling molds and drawing patterns, but for shaking sand or tamping compressed air is better.

F. A. Coleman stated that considering coke, oil, gas and electrically-heated ovens the electric oven alone is increasing in use and decreasing in operating expense. Accuracy of control is a marked advantage. Car-type ovens are preferable for large cores only, while drawer ovens excel in point of fuel cost and ease of control. Rack ovens are best from a handling standpoint. Mr. Knapp, of the General Electric Company, cited an example of one oven producing 11½ lb. of cores per kw.-hr.

Mr. Shepard, president of the Shepard Electric Crane and Hoist Company, advised the use of direct-current cranes, as opposed to alternating-current cranes.

In discussing the paper on electric furnace operation, D. M. Petty stated that the failure of power for more than 15 min. was very serious if it occurred during the finishing process.

Mr. Kennedy thought that the energy consumption mentioned in the paper seemed low, inasmuch as his experience showed that a 15-ton furnace with 24-in. electrodes requires 3,750-kva. transformers. With this furnace trouble occurred because of the burning out of back-wall refractories. Mr. Priestly stated that larger furnaces are needed in the steel industry. His experience showed that 55-ton melts could be made in 40-ton furnaces; also that the larger furnaces are easier to operate and make a more uniform and higher grade of steel.

In closing the discussion, E. T. Moore said that the ideal furnace should be operated with a low-reactance transformer and an external reactor having taps in series. During the refining period the reactance should be short-circuited. He stated that the water rate mentioned in his paper was low as experience showed that it was desirable to operate with at least a 17-deg. temperature difference between the inlet and outlet.

Checking Up Three-Phase Diagrams

(Continued from page 498)

lead for the *A* phase can be located at the top of either group 11 or group 5. In *O* of Fig. 8 the top of group 11 is used. The bottoms of groups 11 and 2 are connected together, the tops of groups 2 and 5 and the bottoms of groups 5 and 8. The top of group 8 forms the last star connection. The tops of groups 8, 10 and 12 may be connected together to form the star point. The jumper numbers are put on at the end of the groups as already explained in reference to Fig. 6.

Line Leads May Be Brought Out at a Number of Points

The small diagram *D* in Fig. 8 represents the star connection, showing the group numbers and the order in which they are passed through. At *E* is shown the way the series-star can be changed to a series-delta connection. The star connection is opened at the end of the *A* phase and connected to the beginning of the *C* phase. Likewise the end of the *C* phase is connected to the beginning of the *B* phase, and the end of the *B* phase to the beginning of the *A* phase. If we enter the delta winding on a line lead all three phases are passed through in the direction of the arrows until the starting point is reached.

In the explanation which has just preceded, directions were given on where to place the line leads. It is not necessary, however, to place the leads always in one position. Fig. 9 shows four different methods of bringing out the line leads. The method shown at *M* is the most common, while that at *O* is used quite frequently. When selecting groups on which to attach line leads keep in mind that the arrows on alternating groups reverse, and assume that the current is flowing in on each line lead.

To check a series-delta connection start at any line lead. This will have attached to it two group connections. For illustration, suppose the *A* lead in *M* of Fig. 10 is taken. This drawing shows a series-delta, top-to-top diagram. As a starting point take one of the connections leading to the *A* lead and so mark it. For instance, in this diagram, take the *A* lead which is connected to group 11. Assume that the current is flowing in on this lead and check the direction of the current through the phase, remembering that every third group (1 and 4) should be passed through and that alternate groups are passed through in opposite directions. At the end of this phase, which is group 8, a connection is made to another line lead, *C*, which also has another group connection, 3, attached to it. Using this lead as the next starting point, check the second phase in the same manner as the first. At the end of the second phase, at group 12, another line connection, *B*, is found. This has another group, group 1, connected to it. Use this connection to group 1 as the start of the third phase. This phase should end on the same line lead on which the first phase started, at group 1. This is the marked lead.

When checking a wound stator, a piece of chalk should be used to mark each group as it is passed through. Instead of making an arrow on the end of the coils composing a group, it is much easier to draw an inclined straight line, as shown in *M* of Fig. 10. The inclination of the line toward the center of the machine indicates the direction of flow of current through the group. These lines have been drawn at groups 4-5-6-7, to illustrate their use.

How Parallel Connections Are Obtained From Series Connections

Changing series to two-parallel and four-parallel connections is shown at *P*, *Q* and *R* of Fig. 8. All the drawings in this figure are for star connections with top-to-top jumpers. Drawings *P*, *Q* and *R* show the *B* phase only. *P* is the drawing giving the series connection of the *B* phase. Drawing *Q* shows the two-parallel connection which is obtained from the series connections. The changed connections in drawing *Q* are shown by the heavy lines. The series of four coils in *P* is cut open at the middle point, the top of group 7 is connected to the *B* line and the bottom of group 10 is connected to the star point.

At *S* is shown the entire two-parallel star connection with all three phases drawn in. Note that the two star connections are not joined together. The electrical performance is not affected by failure to join the two stars and on large machines where the wire is of considerable size, two splices and some cable are saved by omitting the connection between the two stars when a change is made from series to two-parallel.

A four-parallel connection is shown at *R*. Each connection consists of only one group in this case. This is because there are only twelve groups while there are four parallel circuits for each of the three phases. At *T* is shown the complete four-parallel star winding with all three phases drawn in.

The method of drawing and checking parallel-delta connections is shown in Fig. 10 at *N* and *O*. These windings are for top-to-top connections. A two-parallel delta connection will have four taps to each line lead. Then to check the winding take any one line lead as *A* in drawing *N* of Fig. 10. Take any one of the four taps from this line lead, such as the tap connected to group 11. Assume that the current is flowing inward on this tap. Then trace through the groups of this phase, remembering that every third group (1 and 4) is in this phase and that alternate groups should be passed through in opposite directions. Mark all the leads and also the groups as well as the direction in which they are passed through. After the groups in this phase, groups 11 and 2, are passed through, the *C* phase begins. Select a tap on this *C* phase, as that going to group 3. Check through groups 3 and 6 to the *B* line lead. Check this phase through groups 7 and 10. After passing through these three half-phases, we come to the line lead started on, which is *A* in group 10. We shall have marked six taps which were passed. Then starting again on the first line lead, select another tap, this time on group 5, in the *A* phase. Check this circuit through. Then follow each remaining tap at the end of each remaining half-phase until the starting point is reached.

At *O* is a four-parallel, delta connection. Each group is the beginning and the ending of a phase. To check such a winding pass first through any *A* group, then a *C* group, then next a *B* group. This completes the first circuit. Then select another tap leading from a line and pass again through the *A*, *C* and *B* groups. When this is done four times all of the windings will have been included.

The method of constructing a top-to-bottom diagram is shown in Fig. 11. In this type of diagram all

groups in one phase under poles of the same polarity are connected in series. Then a reversing jumper connects this series with the groups under poles of the opposite polarity and these also are all connected in series. When a three-phase motor has top-to-bottom jumpers, groups 1 and 7 are connected together. In *M* of Fig. 11, the top of group 1 is used for a line lead and the bottom connected to the top of group 7. This forms the first series of coils in this phase, as half of the groups in this phase have been covered. Then a short jumper connects the bottom of group 7 to the bottom of group 10. The top of group 10 is then connected to the bottom of group 4, and the top of group 4 forms the star connection. At *N* of Fig. 11 is shown the two-parallel, top-to-bottom connection. Note that the short jumper has been cut open, one end going to a line lead and the other to the star connection.

Other examples of the top-to-bottom connection are included in Fig. 12. This shows a six-pole, series-star diagram, connected top-to-bottom. At *M* is the series connection. At *N* is the two-parallel connection in which the three north-pole groups are in one circuit and the three south-pole groups in the other circuit. In *O* a three-parallel (three-circuit) top-to-bottom connection is shown. In this diagram one of the circuits has a top-to-top connection, where groups 13 and 16 are connected together. The reason is that these two were originally connected together by the short jumper.

Relation of Lighting to Production

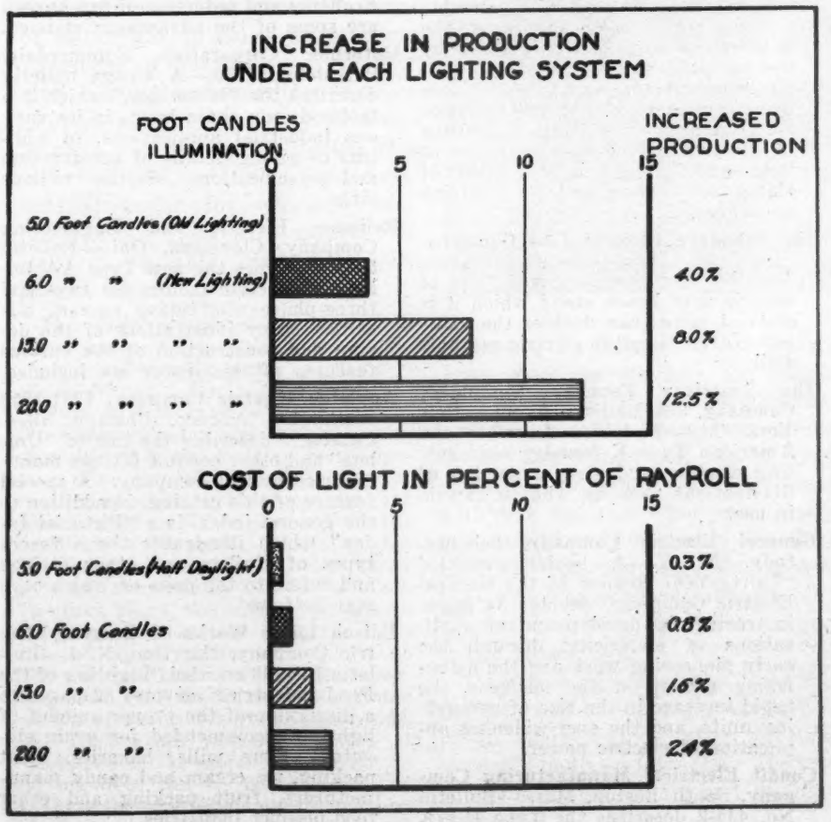
(*Continued from page 488.*)

making a total cost of about 32 cents per hour. With the old 5 foot-candle lighting system, about half of which was daylight, the cost for current and lamp renewals was $0.04 per hour. The inspectors receive an average wage rate of approximately $0.30 per hour or for 44 people a total of $13.20 per hour. A 12.5 per cent increase in production means, therefore, a saving of $1.47 per hour in labor, which is five times the added cost of the lighting.

This is arrived at as follows: A 12.5 per cent increase in production means that less men are needed to obtain 100 per cent production; the number needed would not be 87.5 per cent of the original number but 88.9 per cent. This is easily shown from the equation where X + .125X = 100 per cent; then X=88.9 per cent. Accordingly if only 88.9 per cent of the men are needed with better lighting whereas 100 per cent formerly were required there would be a wage saving of $13.20 minus $13.20 times 88.9 per cent or $1.47 per hour in labor which is five times the added cost of the lighting. To put the matter in another way the new lighting increased production 12.5 per cent at a total cost of less than 2.5 per cent ($0.28÷$13.20) of the payroll of the department where forty-four people were employed.

The authors desire to express their appreciation of the valuable services rendered by Mr. C. M. Snyder in the conduct of the tests which have been described.

Fig. 11—This diagram shows the increase in production under different lighting intensities and the cost of light in per cent of the payroll found by tests conducted in plant of The Timken Roller Bearing Company, Columbus, Ohio.



Rigid and Compression Couplings

(*Continued from page 501.*)

A coupling of the first type is shown at *E*. The sleeve is usually either split or slotted so that as the flanges are tightened up the compression grips the shaft firmly due to a proportionate contraction of the bore. In installing these couplings, care should be taken to see that oil does not get onto the shaft underneath the sleeve and that the bolts are tightened up evenly. Reducing couplings are made either by using a sleeve bored out for the two diameters or by inserting an extra slotted sleeve or bushing equal to the difference in diameter inside the larger sleeve. However, reducing couplings of this type should not be used to connect shafts of more than ½ in. difference in diameter.

Sometimes instead of using the bolted flanges, threaded ring nuts are used. A coupling of this type is shown at *H* and *I*. This type generally uses a key in addition to the gripping strength of the coupling. Here the sleeve is split in half longitudinally and held in place by driving a cone tapered ring on each end, after which the ring nuts are tightened up. As the surface of this coupling is smooth and polished, it is frequently used in textile mills as there are no recesses or projections wherein dirt, dust or lint may collect.

Another compression coupling of this type (*F*) consists of two tapering half-sleeves and two forged steel rings. The split sleeve is turned tapering on the outside and the rings are bored to match. The sleeve is placed over the end of the shaft and the rings driven on as far as they will go. This grips the shaft securely and is easily removed. It is often used on outdoor work as it is easier to drive the rings off than to remove rusted bolts. Straight keys are used with this.

A coupling of the third type is shown as *J* and *K*. In this type of coupling the two cones are drawn together by bolts. As the cones are slotted on one side, the outer sleeve forces them tightly against the shaft.

The fourth type of coupling is very much like the first type of coupling with flanges except that the sleeve is slotted in a spiral instead of longitudinally. The spiral gives a very strong gripping effect.

None of these couplings is adapted to direct-connecting shafts of two high-speed machines because of the difficulty of keeping perfect alignment of the shafts. For this purpose some form of flexible coupling should be used. The various types adaptable will be discussed in another article.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—Bulletin 1046 describes the Type ZK Manual-Automatic Compensators for alternating-current, squirrel-cage motors. Fifteen advantages claimed for this equipment are included.

The Falls Clutch and Machinery Company, Cuyahoga Falls, Ohio—Catalog 18 entitled "Power Transmission Machinery" devotes over 300 pages to engineering information, data, price lists and descriptions of the various lines of shafting, couplings, collars, friction clutches, pulleys, sheaves, bearings and belt tighteners manufactured by this company for transmission purposes.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—A miniature publication entitled "Electric Heat" and devoted to industrial electric heating problems will be published frequently. In addition to articles on the operation and advantages of electric ovens, a method is given for calculating the power requirements for heating electric ovens. Mailed upon request.

Electric Arc Cutting and Welding Company, 152 Jelliff Avenue, Newark, N. J.—A 52-page booklet describes the "Alternarc" portable welding and cutting apparatus, the important feature of which is that by the use of a special transformer alternating current can be used. These transformers may be carried by two men. A number of pages is devoted to illustrations of various types of welds and descriptions of methods of using the welding and rivet-cutting apparatus.

The Standard Electric Tool Company, Cincinnati, Ohio—Recent literature describes the new improved type of electric drill bench stand which it is claimed more than doubles the value and usefulness of an electric portable drill.

The American Foundry Equipment Company, 366 Madison Avenue, New York City—A folder describes the American Type K foundry sand cutting machine and gives a number of illustrations showing what it can do in use.

General Electric Company, Schenectady, N. Y.—A booklet entitled "Thirty-Year Review of the General Electric Company" devotes 34 pages in tracing the development of applications of electricity through the early pioneering work and the astonishing growth of the business, the rapid increase in the size of generating units, and the ever-widening application of electric power.

Condit Electrical Manufacturing Company, South Boston, Mass.—Bulletin No. 445-2 describes the Type D-17A and D-17B oil switches and circuit breakers for manual and electrical control in either automatic or non-automatic types. The capacities range from 7,500 volts to 25,000 volts.

Gisholt Machine Company, Madison, Wis.—A booklet entitled "The Missing Link" describes the use of the "Periodograph" in keeping control of the time spent in production and in idleness in industrial plants.

The Okonite Company, Passaic, N. J.—A booklet entitled "Splices and Tape," discusses the importance of a perfect splice, the important properties of tape, how to recognize these properties, and how to make a perfect splice. A description of the various tapes made by the Okonite Company, and their uses, is included.

The Unique Plumbers' Furnace Company, Tipton, Ind.—Catalog 5 entitled "Unique Soldering Supplies" explains the construction and operation of the "Unique" torches and firepots, burning gasoline and kerosene. Kerosene-burning equipment is provided with a special generator having a large generating surface which, it is claimed, increases the heat obtained and eliminates effect of wind. Economy and reduction of fire hazard are some of the advantages claimed.

Motorbloc Corporation, Summerdale, Philadelphia, Pa.—A 4-page bulletin describes the "Motorbloc," which is a motor-driven chain hoist, in its various industrial applications, in addition to giving details of construction and specifications of the various sizes.

Reliance Electric and Engineering Company, Cleveland, Ohio—Bulletin 5018 describes the new Type AA Reliance induction motors for two- and three-phase alternating current circuits. Many illustrations of the design and construction of the various features of this motor are included.

Appleton Electric Company, 1701-1713 Wellington Avenue, Chicago, Ill.—Catalog 9 describes the line of "Unilets" and other conduit fittings manufactured by this company. A special feature of this catalog, in addition to the general index, is a "Pictorial Index" which illustrates the different types of Unilets and other fittings and refers to the page on which each may be found.

Edison Lamp Works of General Electric Company, Harrison, N. J.—Bulletin LD-143 entitled "Lighting of the Food Industries" devotes 32 pages to a discussion of the proper amount of lighting recommended for grain elevators, flour mills, bakeries, meat packing, ice cream and candy manufacturers, fruit packing and other food-product industries.